REVIEW COPY

RCRA Facility Investigation

CIBA-GEIGY Facility
Cranston, Rhode Island

Draft Stabilization Design Documents

Performance Standards/Performance Monitoring
Shut-Down Criteria/Confirmatory Sampling Plan
Project Management

Submitted By
CIBA-GEIGY Corporation
444 Sawmill River Road
Ardsley, New York 10502

Volume 1 of 4

November 1993
Project No. 87X4660D

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SECTION 1

1.0
INTRODUCTION

1.1 OVERVIEW

This Draft Stabilization Design Document (DSDD) presents the work performed during this design phase of the RCRA Corrective Action at the former CIBA-GEIGY Corporation facility at Cranston, Rhode Island. This chapter presents the background information and organization of the DSDD in four sections:

- Section 1.2 presents the background about the facility, the project and the stabilization program;
- Section 1.3 presents the objectives of the stabilization program;
- Section 1.4 presents the contents and organization of the DSDD; and
- Section 1.5 concludes the chapter.

1.2 BACKGROUND

This section reviews briefly the history of the facility, the history of the project, and the history of the stabilization program. More detailed information on the history of the project and the facility was presented in Chapter 1 of the Phase I Interim Report (submitted in November 1991).

1.2.1 History of the Facility

The Alrose Chemical Company manufactured chemicals at the site starting in 1930. After the GEIGY Chemical Company of New York purchased the facility in 1954 and merged with the Ciba Corporation in 1970, the facility was used for batch manufacturing of organic chemicals. Agricultural products, leather and textile auxiliaries, plastics additives, optical brighteners, pharmaceuticals, and bacteriostats were manufactured at the facility. By May 1986, CIBA-GEIGY had ceased chemical manufacturing operations at the facility and had begun decommissioning and razing the plant.

The site was divided into three study areas - the Production Area, the Waste Water Treatment Area, and the Warwick Area. The boundaries of these three areas are shown in Figure 1-1. The Pawtuxet River (an off-site area) runs through the facility. Twelve solid waste management units (SWMUs) and two areas of concern (AOCs) were identified at the site. For completeness, CIBA-GEIGY identified two additional areas of investigation (AAOIs); based on the Phase I results, AAOI-16 has been designated as SWMU-16. The locations and the Media of Concern to be sampled in each of these

SWMUs, AOCs, and AAOIs also are shown in Figure 1-1. Additional details about these SWMUS, AOCs, and AAOIs (and on past known and/or suspected releases) were presented in Chapter 1 of the Phase I Interim Report and are summarized in Table 1-1.

1.2.2 History of the Project

A draft Administrative Order of Consent (hereafter simply called the "Order") requiring a RCRA Corrective Action Study at the facility was issued to CIBA-GEIGY on 30 September 1988. After negotiations and evaluation of public comments, the Order was signed by CIBA-GEIGY on 9 June 1989 and became effective on 16 June 1989. In 1987, EPA conducted the Facility Assessment to identify known and/or suspected releases at the facility requiring further action. The results were presented in the Final RFA Report, CIBA-GEIGY RCRA Facility Assessment (January 1988). In 1988, CIBA-GEIGY conducted a Preliminary Investigation (not required by the Order) to begin characterizing the facility's environment and selected releases; the results were summarized in the Current Assessment Summary Report.

The RCRA Facility Investigation will characterize the impact of known and/or suspected releases that were determined by the Facility Assessment to require further action. The Facility Investigation is being conducted in two phases; Phase I was conducted in two parts (Phases IA and IB) to obtain additional guidance from USEPA throughout the project. Phase IA was conducted in late 1989 and mid-1990 to characterize the facility's physical environment more completely; the results of Phase IA were presented in the Phase IA Report (October 1990). Phase IB was conducted in late 1990 and early 1991 to characterize the impact of known and/or suspected releases at the facility more completely and to provide additional information about the facility's physical environment.

The Phase I Interim Report (submitted in November 1991) presented the results of Phases IA and IB. In particular, the Phase I results indicated that constituents are present in the groundwater in the Production Area and in the soil in SWMU-11. Because the risk assessment has not yet been conducted, no imminent threat to human health or the environment has been determined. Phase II will begin after the USEPA approves the Phase II Proposal (submitted in November 1991) and/or the Phase II Pawtuxet River Proposal (submitted in January 1992), and will entail additional site characterization and sampling, the risk assessment, and the Media Protection Standards (MPS) Proposal.

1.2.3 History and Phases of the Stabilization Program

Stabilization is a new approach for controlling releases at selected RCRA facilities and is intended to prevent or minimize further migration of contaminants while long-term corrective action remedies are evaluated. The USEPA envisions that stabilization measures will be identified and implemented under the interim measures authority with the ongoing Facility Investigation activities.

In April 1992, the possibility of taking a stabilization approach at the facility was discussed in a meeting with the USEPA; in early May, the USEPA and CIBA-GEIGY agreed to pursue a stabilization program in the Production Area at the facility. The stabilization program was integrated into the RCRA Facility Investigation through a Modification of the Order executed on 28 September 1992. The Stabilization Work Plan was submitted to the USEPA in September 1992, and conditional approval of the work plan was granted on 21 December 1992.

Overall, this stabilization program involves three phases:

1. Investigation, including developing the Stabilization Work Plan, conducting field work, and reporting the results of the field work in this Stabilization Investigation Report;

2. Design, including developing the Design Concepts Proposal (submitted to USEPA in May 1992 along with the Stabilization Investigation Report), developing this Draft Stabilization Design Documents, revising the Draft Stabilization Design Documents after USEPA review and producing the Final Stabilization Design Documents.

3. Implementation, including permitting, construction and operation of the treatment(s) and/or actions proposed and approved. The Stabilization Report(s) will be developed and submitted after the performance standards for stabilization have been met.

1.3 OBJECTIVES OF STABILIZATION

This section reviews the objectives of the stabilization program overall and describes the objectives and scope of the design phase of the stabilization program.

1.3.1 Objectives of the Stabilization Program

Overall, the three phases of the stabilization program are designed to meet two objectives:

1. Prevent or minimize contaminated groundwater in the Production Area from migrating into the Pawtuxet River.

2. Reduce concentrations of volatile organic compounds in the soil (unsaturated zone) and groundwater (saturated zone) at SWMU-11.

1.3.2 Objectives and Scope of the Design Phase

The design phase of the stabilization program has two objectives:

1. Based on the results of the aquifer and treatability tests, design an effective full-scale groundwater capture and pretreatment system for the Production Area.

2. Based on the results of the vapor extraction pilot test in both the aqueous and vapor phases at SWMU-11, design a full-scale soil vapor extraction (SVE) system for SWMU-11.

In general, the scope of the design phase includes:

1. developing detailed design drawings and technical information for a groundwater capture system in the Production Area;

2. developing detailed design drawings and technical information for a full-scale groundwater pretreatment system in the Production Area; and

3. developing detailed design drawings and technical information for a full-scale soil vapor extraction system at SWMU-11.

1.4 ORGANIZATION OF THIS DOCUMENT

The DSDD includes the following five (5) items in four (4) volumes:

- Performance standards for the three stabilization systems (presented in Chapter 2 of this document);

- A confirmatory sampling plan (presented in Chapter 3 of this document) for the stabilization systems;

- Draft technical specifications (Divisions 1 through 16) for the construction of the stabilization action systems is presented in Volume 2;

- A draft operation and maintenance (O&M) manual for the stabilization action systems is presented in Volume 3; and

- Draft detailed design drawings for the construction of the three stabilization action systems in Volume 4.

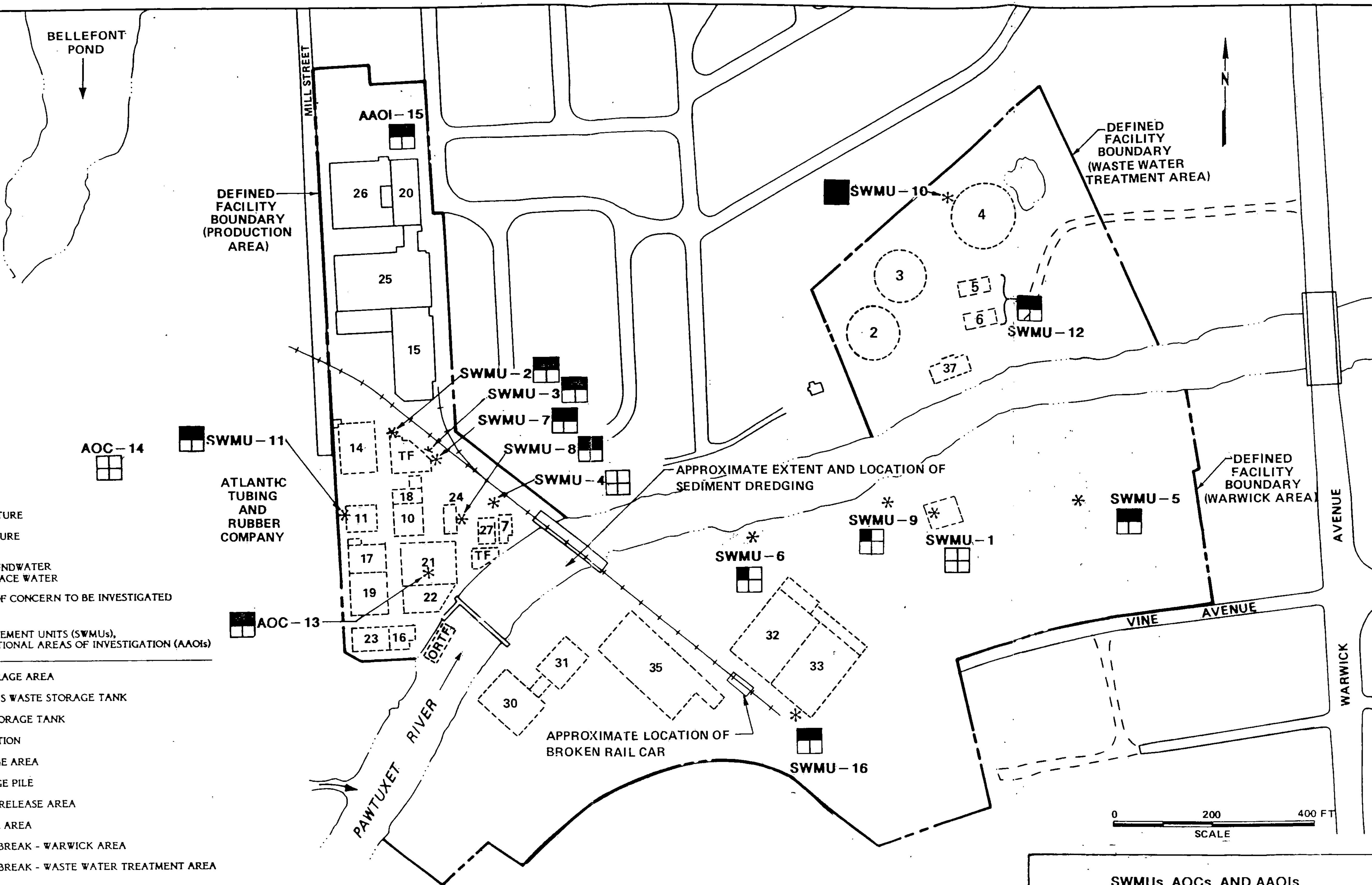
1.5 SUMMARY

This chapter reviewed the background about the stabilization program and described the contents and organization of the DSDD.

Stabilization is a new approach for controlling releases at selected RCRA facilities and is intended to prevent or minimize further migration of contaminants while long-term corrective action remedies are evaluated. In early May 1992, the USEPA and CIBA-GEIGY agreed to pursue a stabilization program in the Production Area at the former Cranston facility. The stabilization program was integrated into the RCRA Facility Investigation through a Modification of the Order executed on 28 September 1992. The Stabilization program involves 1) investigation, conducting field work, and reporting the results of the field work in the Stabilization Investigation Report and 2) Development of the Draft Stabilization Design Documents and after USEPA review producing the Final Stabilization Design Documents.

The DSDD includes five (5) items in four (4) volumes. Performance standards and a confirmatory sampling plan are presented in Chapters 2 and 3 of Volume 1. Draft technical specifications for the systems are presented in Volume 2 and the operation and maintenance (O&M) manual is presented in Volume 3. Detailed design drawings are presented in Volume 4.

The next chapter discusses the functional description for the stabilization action.



LEGEND:

* LOCATION OF SWMU

LOCATION OF EXISTING STRUCTURE

LOCATION OF FORMER STRUCTURE

SOIL — GROUNDWATER
SEDIMENT — SURFACE WATER

SHADED QUADRANTS INDICATE MEDIA OF CONCERN TO BE INVESTIGATED

SOLID WASTE MANAGEMENT UNITS (SWMUs),
AREAS OF CONCERN (AOCs), AND ADDITIONAL AREAS OF INVESTIGATION (AAOIs)

SWMU-1	HAZARDOUS WASTE STORAGE AREA
SWMU-2	6000-GALLON HAZARDOUS WASTE STORAGE TANK
SWMU-3	7500-GALLON, 90-DAY STORAGE TANK
SWMU-4	TRASH COMPACTOR STATION
SWMU-5	RIVER SEDIMENT STORAGE AREA
SWMU-6	ZINC OXIDE/SOIL STORAGE PILE
SWMU-7	CHLOROSULFONIC ACID RELEASE AREA
SWMU-8	PRUSSIAN BLUE RELEASE AREA
SWMU-9	WASTE WATER PIPELINE BREAK - WARWICK AREA
SWMU-10	WASTE WATER PIPELINE BREAK - WASTE WATER TREATMENT AREA
SWMU-11	TOLUENE RELEASE AREA
SWMU-12	WASTE WATER TREATMENT PLANT
AOC-13	PROCESS BUILDING AREA
AOC-14	ATLANTIC TUBING AND RUBBER COMPANY PROPERTY
AAOI-15	LABORATORY BUILDING WASTE WATER SUMP
SWMU-16	MAINTENANCE DEPARTMENT CLEANING AREA

NOTES:

1. STRUCTURE LEGEND IS INCLUDED IN THE RCRA FACILITY INVESTIGATION PROPOSAL, CHAPTER 1, FIGURE 3 – 1.
2. CIBA – GEIGY HAS IDENTIFIED ONE ADDITIONAL AREA OF INVESTIGATION (AAOI). THIS AAOI HAS BEEN DESIGNATED AS AAOI – 15.

BASE MAP SOURCE: GEOD CORPORATION OF NEWFOUNDLAND, NEW JERSEY, MAPPED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHS. DATE FLOWN: 2 APRIL 1989

SWMUs, AOCs, AND AAOIs

WOODWARD – CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY:	KF	SCALE:	1:2400	PROJ. NO.:	87X4660
CK'D. BY:	MH	DATE:	20 JAN 1992	FIG. NO.:	1 – 1

SECTION 2

2.0
FUNCTIONAL DESCRIPTION

2.1 OVERVIEW

The functional description is a written description of the unit processes, parameters controlled/monitored, interlocks and alarm conditions associated with the stabilization action. A summary of the functional description is presented here. The full functional description for the stabilization action is presented in Section 4 of Volume 3 (Operation and Maintenance manual) of the DSDD. Process flow diagrams for the groundwater capture system, groundwater pretreatment system, and the soil vapor extraction (SVE) system are presented in Figure 2-1 through 2-3 respectively.

2.2 GROUNDWATER CAPTURE SYSTEM

~~FREEZE PROBLEM?~~ WILL BE HEATED!

Groundwater will be pumped from two to four recovery wells in the Production Area. The groundwater will be conveyed via an above-grade forcemain to the groundwater pretreatment system. To ensure that the required hydraulic gradient reversal is maintained, water levels in selected in-river and Production Area monitoring wells/piezometers will be monitored. The static water level in the in-river monitoring wells (located on the river side of the bulkhead) will be compared to the corresponding Production Area wells to determine gradient reversal. A differential static water level of up to two-feet will be maintained automatically between the in-river well and its corresponding Production Area monitoring well/piezometer by adjusting the flowrate from each recovery well.

A compact programmable logic controller (PLC) will be provided for each recovery well to control the pumping rate and monitor drawdown. The recovery well PLCs will be linked to the main PLC located in the control room. The recovery well PLC, motor-starter, instrumentation, and associated piping/valves will be housed in a small pre-engineered structure around the well. The discharge from each recovery well will be conveyed to a common header and forcemain to the groundwater pretreatment system.

2.3 GROUNDWATER PRETREATMENT SYSTEM

The groundwater pretreatment system is designed to remove metals and volatile organic compounds from the groundwater. The groundwater pretreatment system consists of aqueous-phase treatment; vapor-phase treatment; and sludge handling/dewatering.

2.3.1 Aqueous-Phase Treatment

Groundwater pumped from the groundwater capture system and soil vapor extraction (SVE) system will receive on-site pretreatment prior to discharge. Equalization will be

VOA's will be released to air? / Are tanks closed? — YES!

provided to minimize the fluctuations in groundwater flow and contaminant loading to the pretreatment system. Two equalization tanks will be provided for this system. Equalization Tank No. 1 will be provided for groundwater extracted by the groundwater capture system while Equalization Tank No. 2 will be provided for the groundwater extracted by the soil vapor extraction (SVE) system. Agitators will be provided in both equalization tanks to ensure a "complete-mix" condition.

Equalized groundwater will be pumped to the oxidation and deaeration/pH adjustment tanks. Dissolved ferrous iron in the groundwater will be oxidized with air to the less soluble ferric iron. A low-pressure centrifugal blower will provide the air supply required for oxidation. As the conversion occurs, the pH of the groundwater will drop slightly as a result of hydrogen ion production. Adjustment of the groundwater pH will take place with a 20 percent solution of sodium hydroxide (NaOH).

A chemical oxidation system will be provided using 35 percent hydrogen peroxide (H_2O_2) as a back-up, should air oxidation be unable to facilitate the complete conversion of the dissolved iron and manganese in the groundwater. A hydraulic retention time (HRT) of about 30-minutes will be provided to ensure sufficient time for oxidation and pH adjustment to occur.

A deaeration stage will be provided to allow the air bubbles entrained on the metal sludge particles during air oxidation to be released, thus improving sludge settling. A separate pH adjustment system will provided in this stage to adjust the groundwater pH, if required. NaOH (20 percent) will be used for pH adjustment. An HRT of about 30-minutes will be provided in the deaeration/pH adjustment tank.

An inclined-plate separator will be provided to remove the metal precipitates formed during the air-oxidation process. A flash mixing zone, flocculation zone, and gravity settling zone will be provided in the plate separator. High molecular weight anionic polymer will be added to the flash-mix zone of the separator to enhance flocculation. The insoluble metal floc will form in the flocculation zone and settle to the bottom of the separator's internal sludge thickener. Excess sludge will be transferred to the sludge holding tank. A portion of the settled sludge will be pumped to the oxidation tank to enhance the floc formation. The supernatant from the separator will exit from the top of the inclined-plate separator and flow by gravity to the sand filter.

A Parkson Dynasand (continuous backwashing) filter will be used to remove any residual suspended solids in the overflow from the inclined-plate separator prior to air stripping. As the groundwater flows upwards through the sand bed, residual suspended solid particles will be trapped in the filter media. A compressed air source will provide a continuous air scour to help clean the sand filter. The reject (backwash) water generated by the filtering operation (5 to 7 percent of the total flow) will flow by gravity to Lift Station No. 3 where it will be pumped to Equalization Tank No. 1.

Three (3) intermediate lift stations will be utilized to convey the groundwater through the pretreatment system. Lift Station No. 1 will pump groundwater from the Dynasand filter to the air stripper while Lift Station No. 2 will pump groundwater from the bottom of the air stripper to the activated carbon adsorption units. Lift Station No. 3 will be used to convey the Dynasand filter reject, sludge holding tank overflow and floor washing's to Equalization Tank No. 1. All three lift stations will consist of a wet-well and two transfer pumps. A HRT of about 15 minutes will be provided in each lift station's wet-well to minimize the number of pump starts. An agitator will be added to Lift Station No. 3 to prevent solids from settling in the wet-well.

A Delta Cooling Towers down-flow countercurrent air stripper will be used to remove the VOCs from the groundwater. Air for the stripper will be supplied by a separate low-pressure blower. Groundwater will be pumped to the air stripper via Lift Station No. 1. An in-line organic analyzer will be provided to control the flow to the stripper from the lift station. As organic concentrations increase, flow to the stripper will be reduced, thus increasing the effective air-to-water ratio of the unit. Differential pressure in the stripper will be monitored to indicate possible fouling of the unit.

Following air stripping, activated carbon will be provided to remove any residual organic compounds prior to discharge. Two (2) activated carbon units will be provided. The units can be operated in either parallel or series. The aqueous-phase activated carbon system will be provided with a backwashing system. Backwashing operations will be initiated manually but carried out automatically. Backwashing will be performed on a regular schedule, about once per week. During backwashing, the carbon bed will be expanded with City water for a period of about 20 minutes. Water from backwashing operations will flow directly to Equalization Tank No. 1. The carbon units will be operated in series and samples will be collected manually between the two units to determine breakthrough. When the capacity of the "lead" carbon unit has been exhausted, carbon replacement will be scheduled.

A final pH control system will be provided to adjust the pH of the effluent before being discharged to the sanitary sewer. Sulfuric acid (H_2SO_4) will be used to reduce the pH of the groundwater. An HRT of about 20 minutes will be provided in the final pH adjustment tank.

2.3.2 Vapor-phase Treatment

Moist air discharged from the air stripper (and several process tanks in the pretreatment system) will be treated using vapor-phase activated carbon. A dehumidifier will be provided prior to the carbon unit to reduce the relative humidity of the air. Piping, valves and space for 2 vapor-phase carbon units will be provided, however, only one unit will be in operation at any one time. Once treated, the air will be discharged to the atmosphere.

2.3.3 Sludge Handling/Dewatering System

A sludge holding tank will be provided to reduce the number of sludge dewatering operations required to about once per week. The sludge tank will have a 45° cone bottom to allow the sludge to thicken further before being pumped to the filter press. The supernatant from the sludge holding tank will be conveyed by gravity to Lift Station No. 3.

Sludge generated during groundwater pretreatment will be dewatered using a recessed plate filter press. The sludge will be dewatered to a dry solids concentration of between 20 and 30 percent. The sludge cake will be disposed of off-site. All sludge dewatering operations will be initiated manually and then allowed to proceed automatically. Filtrate from dewatering operations will flow by gravity to Lift Station No. 3.

2.4 SOIL VAPOR EXTRACTION (SVE) SYSTEM

The SVE system is designed to remove VOCs from the soil and groundwater in the SWMU-11 area. The main SVE panel will provide control for all the major SVE components. The PLC provided for the SVE system will be integrated with the main PLC located in Building No. 15. The major SVE equipment will be installed in a trailer located near SWMU-11. The trailer will be partitioned into two zones for electrical classification purposes; one will be classified hazardous (Class 1, Division 1, Group D), the other will be classified non-hazardous. A sealed partition wall and forced air ventilation system will be provided to separate the two zones. The SVE system will consist of a water/vapor extraction system and a thermal/catalytic oxidizer for the treatment of the gas stream.

?

2.4.1 Water/Vapor Extraction System

SEE FIG 2-4 MW-14S

YES

A total of seven wells will be used for water/vapor extraction in the SWMU-11 area. The seven wells are presented in Figure 2-4. Wells VE-1, VE-2, VE-3 and VE-4 will be used for both soil vapor and water (dual-phase) extraction. The remaining three wells (VE-7, VE-9, VE-10) will be used to extract contaminated groundwater in the SWMU-11 area only.

Groundwater and soil vapor will be extracted independently from each of the four dual-phase extraction wells. Soil vapor will be extracted directly from a connection to the well riser, while groundwater will be extracted from each well through a coaxial straw, which will extend into the well below the static groundwater level. Each extraction well will be connected to the water and vapor extraction manifolds. A liquid level sensor at each well will be used to automatically control the water and vapor extraction manifold solenoid valves.

Six additional observation wells will be used to monitor the influence of the dual-phase extraction and groundwater recovery system. These monitoring wells include: VE-4, VE-5, VE-6, VE-8, MW-4S and P-4S. These monitoring wells are also presented in Figure 2-2.

A positive-displacement, lobe-type vacuum ~~blower will~~ used to extract soil vapor from the extraction wells and transfer it to the thermal oxidizer. The vapor extraction tank will provide a pneumatic vacuum reservoir for the vapor and function as a knockout/receiver tank for removal of water droplets, condensate and particulates that may be entrained in the incoming vapor. Liquid-level sensors in the vapor extraction tank will automatically control the discharge of any accumulated water in the tank.

Dual progressive-cavity (positive-displacement) pumps will be used to extract groundwater from the extraction wells. Extracted groundwater will be pumped to Equalization Tank No. 2. The groundwater extraction pumps will be controlled by the vacuum pressure sensor on the water extraction tank.

2.4.2 Thermal/Catalytic Oxidizer

A thermal/catalytic oxidizer will be installed adjacent to the equipment trailer for the destruction of VOCs from the SVE system. The control panel for the oxidizer will be provided with an outside air purge system to prevent the system from being operated until the panel interior has been suitably purged of possible VOCs. Operation of the oxidizer will be a prerequisite for the operation of the SVE system. A shut-down condition at the oxidizer will result in a shut-down of the SVE System. The thermal oxidizer will be supplied with its own control panel, which will be interlocked with the SVE control system. The oxidizer must reach an operating temperature of 140^{0}F before the SVE will be able to start-up.

2.5 SUMMARY

An executive summary of the functional description for the three stabilization systems is provided in this section. The full functional description for the stabilization action is presented in Section 4 of Volume 3 (Operation and Maintenance manual).

Groundwater Capture System

Groundwater will be pumped from two to four recovery wells in the Production Area and conveyed to the groundwater pretreatment system. Water levels in selected in-river and Production Area monitoring wells/piezometers will be monitored to determine if the gradient is reversed. A differential static water level of up to two-feet will be maintained between the in-river well and its corresponding Production Area monitoring well/piezometer by adjusting the flowrate from each recovery well.

Groundwater Pretreatment System

Groundwater pumped from the groundwater capture and SVE system will be pretreated on-site prior to discharge. The groundwater pretreatment system is designed to remove metals and VOCs from the pumped groundwater. The groundwater pretreatment system consists of aqueous-phase treatment; vapor-phase treatment; and sludge handling/dewatering. Equalization will be provided to minimize the fluctuations in groundwater flow and contaminant loading. Dissolved ferrous iron in the groundwater will be oxidized using air. A chemical oxidation system using hydrogen peroxide (H_2O_2) will be provided as a back-up should air oxidation be unable to facilitate the complete conversion of the dissolved iron and manganese in the groundwater.

An inclined-plate separator will be provided to remove the metal precipitates formed during the air-oxidation and deaeration steps. Excess sludge will be transferred to the sludge holding tank. The Parkson Dynasand filter will remove any residual suspended solids in the overflow prior to air stripping. A down-flow countercurrent air stripper will be provided to remove volatile organics from the groundwater. Activated carbon will be provided to remove any residual organic compounds prior to discharge. A final pH control system will be provided to adjust the pH of the treated groundwater to within the permitted range of values before being discharged to the sanitary sewer.

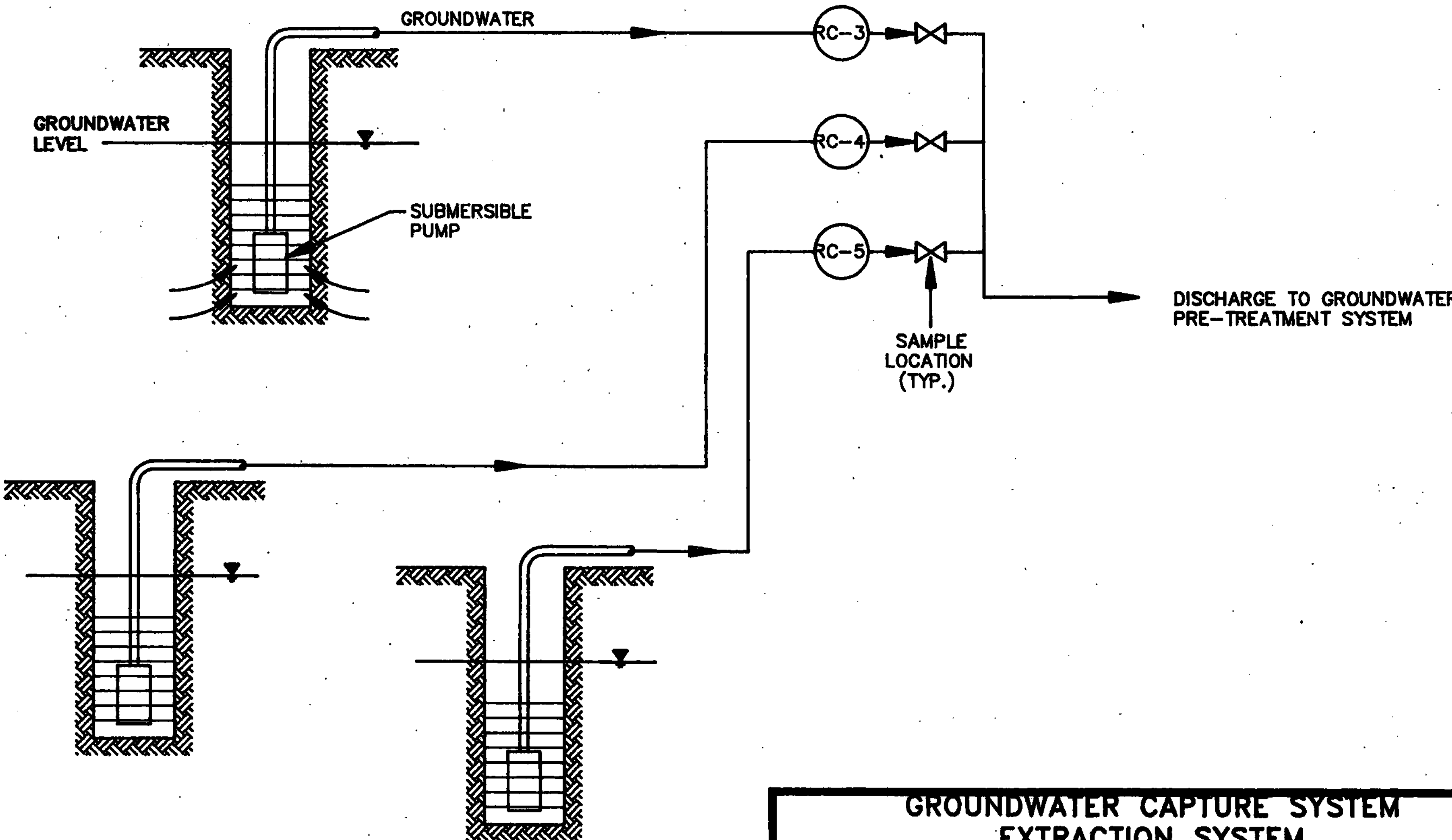
Moist air discharged from the air stripper will be treated using vapor-phase activated carbon. Once treated, the air will be discharged to the atmosphere. Sludge generated during groundwater pretreatment will be dewatered using a recessed plate filter press.

Soil Vapor Extraction (SVE) System

The PLC for the SVE system will be integrated with the main PLC located in Building 15. The SVE equipment will be installed in a trailer located near SWMU-11. The SVE system will consist of a water/vapor extraction system and a thermal/catalytic oxidizer. The SVE system for SWMU-11 will consist of four dual-phase and three groundwater only recovery wells. The four dual-phase recovery wells will be operated independently to extract groundwater and soil vapor from the subsurface. A positive-displacement, lobe-type vacuum blower will be used to extract soil vapor from the extraction wells and transfer it to the thermal oxidizer. Dual progressive-cavity (positive-displacement) pumps will be used to extract groundwater from the extraction wells. Extracted groundwater will be pumped to Equalization Tank No. 2.

A thermal/catalytic oxidizer will be installed adjacent to the equipment trailer for the SVE system. All vapors from the SVE system will be conveyed to the oxidizer for treatment prior to discharge to the atmosphere.

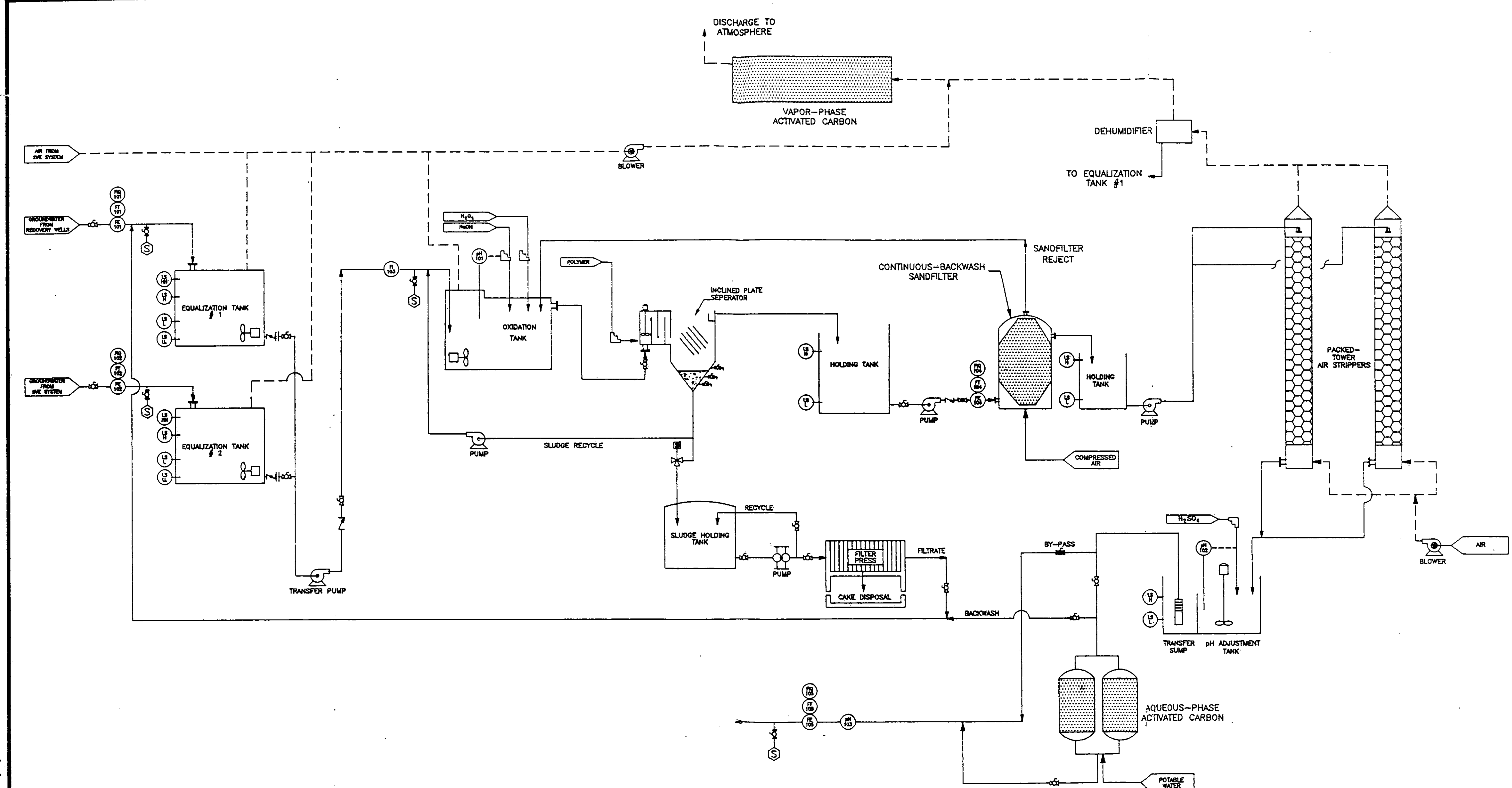
The next chapter discusses the performance standards for the stabilization action.



GROUNDWATER CAPTURE SYSTEM
EXTRACTION SYSTEM
PROCESS FLOW DIAGRAM

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR.BY	BTM	SCALE	AS SHOWN	PROJ.	87X4660
CK'D.BY	JC	DATE	APRIL 27, 1993	FIG.NO.	2-1



S — SAMPLE LOCATION	FE 101 — FLOW ELEMENT
LS H — LEVEL SWITCH-HIGH	FIQ 101 — FLOW INDICATER/TOTALIZER
LS L — LEVEL SWITCH-LOW	FT 101 — FLOW TRANSMITTER
pH 101 — pH ELEMENT	

PROCESS FLOW DIAGRAM FOR THE FULL-SCALE GROUNDWATER PRETREATMENT SYSTEM

WOODWARD-CLYDE CONSULTANTS

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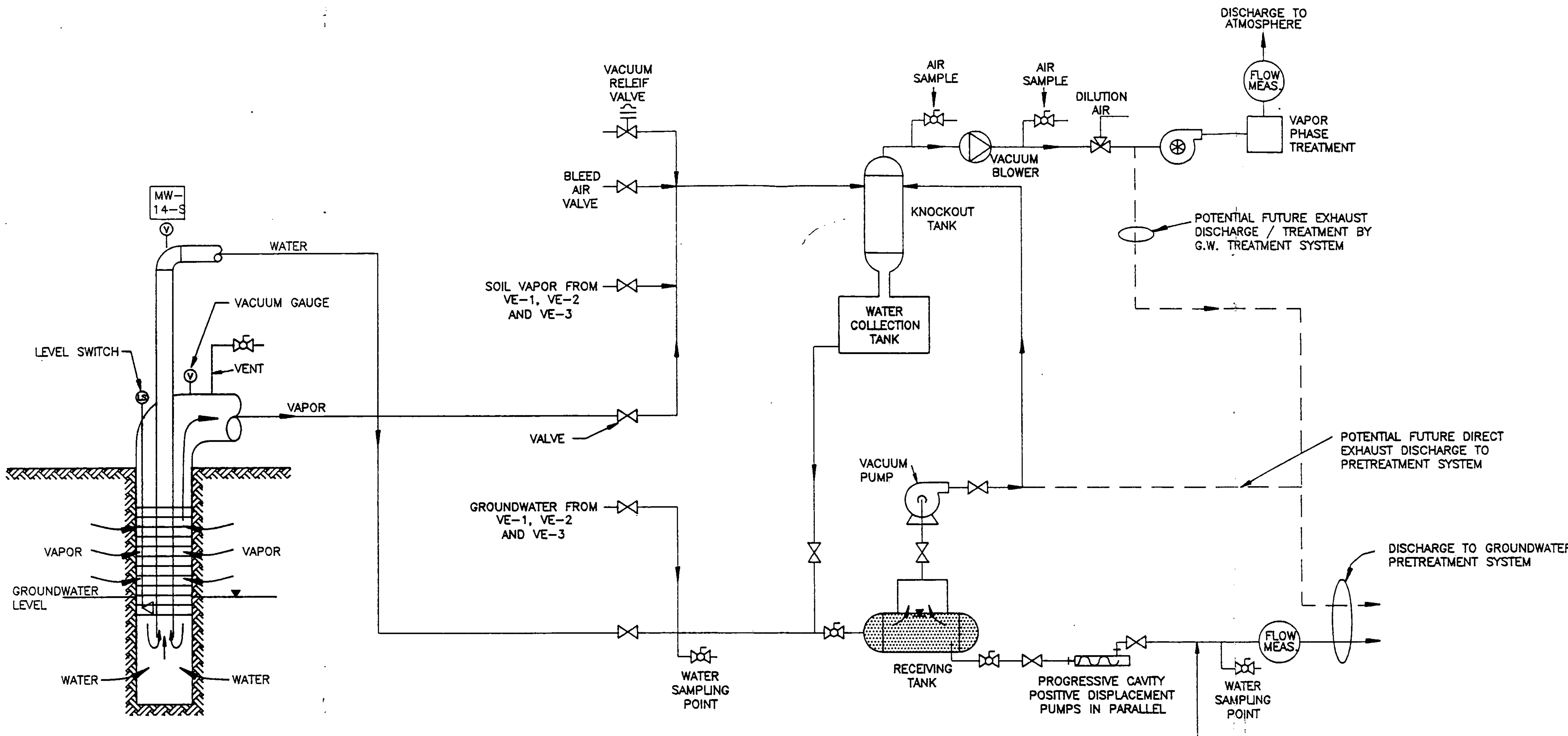
WAYNE, NEW JERSEY

DR.BY	MVB	SCALE	NONE	PROJ.	87X4660
CK'D.BY	JJC	DATE	APR 12 1993	DWG.NO.	2-2

File name: C:\DWG\PLOT1.DWG Last edited: 93/04/29 @ 12:44



TYPICAL WELL CONFIGURATION

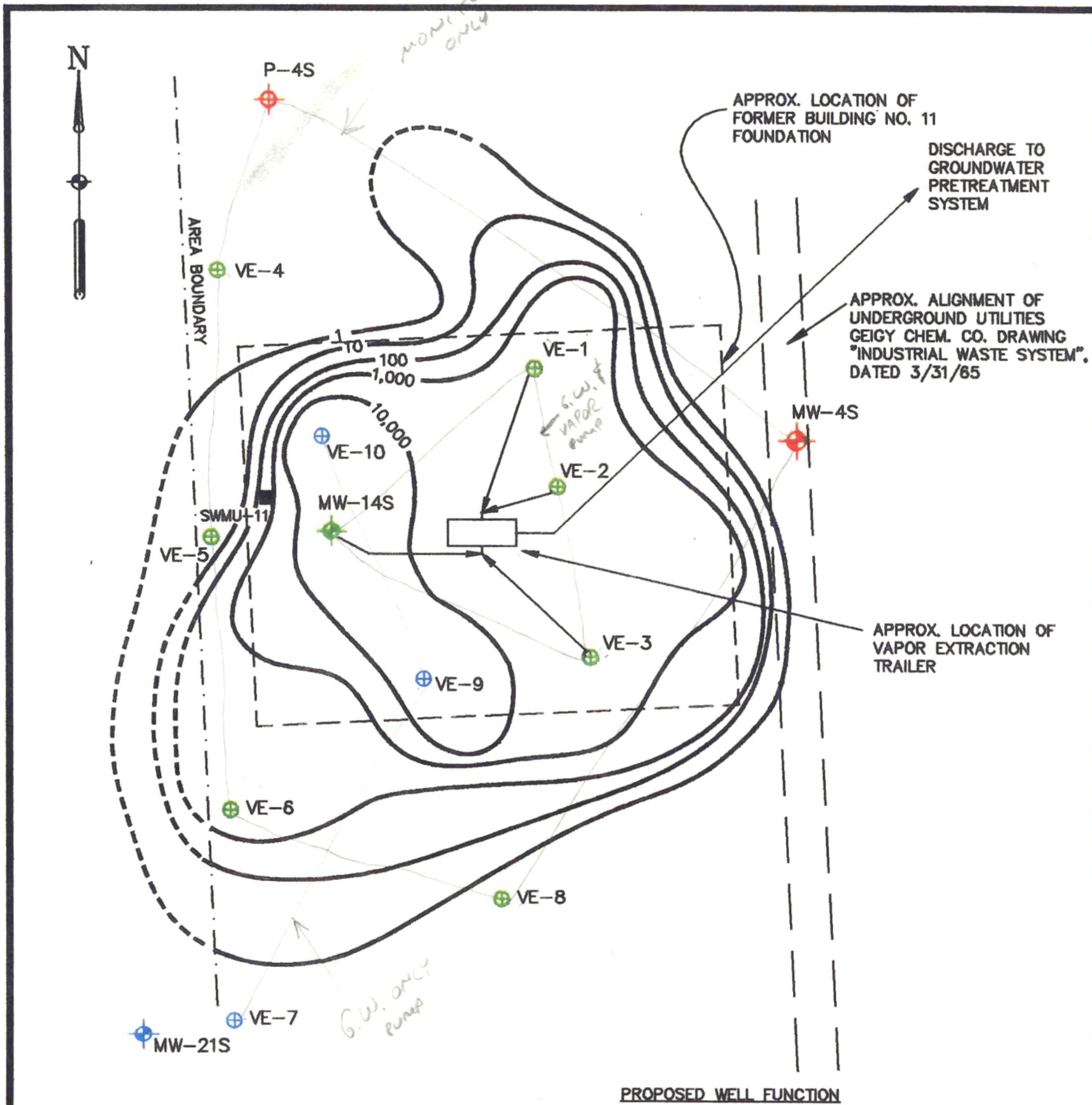
PROCESS FLOW DIAGRAM FOR THE SOIL VAPOR EXTRACTION SYSTEM

WOODWARD-CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR.BY	BTM	SCALE	NONE	PROJ.	87X4660
CK'D.BY	TAM	DATE	APRIL 28, 1993	FIG.NO.	2-3

File name: C:\DWG\PLOT1.DWG Last edited: 93/04/29 @ 11:56



PROPOSED WELL FUNCTION

- SOIL VAPOR EXTRACTION AND GROUNDWATER PUMPING
- GROUNDWATER PUMPING/ OBSERVATION WELL
- OBSERVATION WELL

LEGEND:

- EXISTING MONITORING WELL
- EXISTING PIEZOMETER
- EXISTING VAPOR EXTRACTION WELL
- 10 ISOCONCENTRATION LINE (ppbv)

SOURCE OF BASE: TRACER RESEARCH CO.

File name: K:\CADD\87X4660\FIG2-4.DWG Last edited: 03/11/23 @ 14:54

WELL LOCATIONS FOR THE SOIL VAPOR EXTRACTION SYSTEM

WOODWARD-CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR.BY	BTM	SCALE	1 : 300	PROJ.	87X4660
CK'D.BY	TAM	DATE	NOV 23, 1993	FIG.NO.	2-4

SECTION 3

3.0
PERFORMANCE STANDARDS
PERFORMANCE MONITORING

3.1 OVERVIEW

This chapter presents the performance standards for the three stabilization systems. The performance standards for the *groundwater capture system* are designed to minimize the migration of contaminated groundwater from the Production Area to the Pawtuxet River. The performance standards for the *groundwater pretreatment system* are designed to remove constituents in the groundwater prior to discharge to the POTW; and the performance standards for the *soil vapor extraction (SVE) system* are designed to remove VOCs in the soil and groundwater at SWMU-11.

Performance standards for the three stabilization systems are discussed in three sections:

- Section 3.2 presents the performance standards and performance monitoring for the groundwater capture system;
- Section 3.3 presents the performance standards and performance monitoring for the pretreatment system (aqueous and vapor phase); and
- Section 3.3 presents the performance standards and performance monitoring for the soil vapor extraction system.

3.2 GROUNDWATER CAPTURE SYSTEM

3.2.1 Performance Standards

The groundwater capture system includes two to four pumping wells to reverse the hydraulic gradient at the bulkhead from its present direction towards the Pawtuxet River. Gradient reversal is achieved when water levels are lower on the landward side of the bulkhead than on the Pawtuxet River side of the bulkhead. Details of the well design for the groundwater capture system are presented in Appendix A.

The performance of the groundwater capture system is based on its ability to reverse the hydraulic gradient at the bulkhead. The current hydraulic gradient across the bulkhead (and its variation over time) was evaluated to establish the initial performance standards. Water level elevations measured during the period of November 1992, through August 1993, were evaluated. (November 30, 1992 was the date that the first round of water level measurements were collected after piezometers P-35S, P-36S, P-37S and P-38S were installed in the Production Area).

Representative hydraulic gradients were determined from well and/or piezometer couplets that were located on both sides of the bulkhead. The well/piezometer couplets used to determine the hydraulic gradient are presented below:

Production Area Monitoring Point	In River Monitoring Point
P-35S	MW-31S
P-2D	MW-31D
P-1S	MW-30S
P-1D	MW-30D
P-37S	MW-29S

The difference in water level elevations and the hydraulic gradient between the Production Area monitoring points and the in-river wells are presented in Table 3-1. The hydraulic gradient was determined by subtracting the groundwater elevation in the river-well from the groundwater elevation in the corresponding Production Area monitoring point and then dividing that number by the distance between the two points. A negative hydraulic gradient indicates a potential for groundwater flow towards the river.

As shown in Table 3-1, most of the hydraulic gradients from the nine measurement periods are negative, indicating that the groundwater flow is mostly towards the river. The average difference in water level elevations varied from -0.27 to -1.39 feet. The corresponding average hydraulic gradient varied from -0.02 to -0.06 feet/foot. The smallest difference in water level elevations and hydraulic gradient were noted at P-35S and MW-31S near the southern end of the bulkhead, while the largest difference was noted at P-37S and MW-29S near the northern end of the bulkhead in the Production Area.

Based on the nine water level measurements presented in Table 3-1 and the preliminary hydraulic gradient calculations, the following minimum drawdown goals are proposed for the groundwater capture system:

PERF. #1 STD.

OK

BUT INCLUDE MORE LOCATIONS

- 0.5 feet of drawdown in the southern portion of the Bulkhead as measured by the difference in water elevations between P-35S and MW-31S;
- 1.0 feet of drawdown in the center portion of the Bulkhead as measured by the difference in water level elevations between ~~[illegible]~~ P-1S and MW-30S; and
- 1.7 feet of drawdown in the northern portion of the Bulkhead as measured by the difference in water level elevations between P-37S and MW-29S.

A graphic presentation of the proposed drawdown goals for the stabilization system is presented in Figure 3-1.

The proposed drawdown goals are based on the average water-level difference across the bulkhead at each of the measuring points with about 20 percent additional drawdown added to provide a safety factor. This safety factor was added to insure that gradient reversal will be maintained. (It is customary to add a safety factor in designing groundwater recovery systems due to variations in water levels and the variability of the measurements collected).

The reversed hydraulic gradient, which is based on the difference in groundwater elevations on both sides of the bulkhead, will vary with seasonal groundwater fluctuations and precipitation. Seasonal water level fluctuations occur slowly and can be compensated for in the controlled drawdown of the recovery wells that are required to maintain the reversed hydraulic gradient.

Changes in water level elevations from precipitation occur within 24-hours of a rainfall event. The water level monitoring data presented in the Stabilization Investigation Report and Design Concepts Proposal (May, 1993) show the effect of rainfall on water levels. In general, precipitation events greater than 1.0 inch in 24 hours caused water level elevation rises in each of the wells monitored continuously in the Production Area. A large recent storm event (December 10, 1992) caused water level increases of up to 2 feet in the wells located near the river.

The 30-day constant rate test data (Appendix J of the Stabilization Investigation Report and Design Concepts Proposal) shows consistent increases in water levels in the wells and piezometers on both sides of the bulkhead after a rainfall event. The relative difference in groundwater elevations on both sides of the bulkhead remains similar after a rainfall event, indicating that the gradient also remains unchanged. Once the reversed hydraulic gradient was established during the test, it was not changed by a rainfall event. As a result, additional pumping during a rainfall event to compensate for the increased water level elevations is not required. However, capping of the Production Area could reduce the volume of water required to be captured and may reduce the transport of contaminants in the groundwater.

Maintaining a reversed hydraulic gradient during the 30-day constant rate test was demonstrated by water elevation data collected for P-37S and MW-29S during the 30-day constant rate test, which showed the following (based on Figures J-8 and J-19 in Appendix J of the Stabilization Investigation Report and Design Concepts Proposal):

- a water level difference of -1.45 feet and a gradient of -0.06 feet/foot was measured (toward the river) prior to the start of the test (November 30, 1992):

- a water level difference of 0.59 feet and a gradient of 0.02 feet/foot was measured (towards the Production Area) after 10 days of pumping RC-1 and RC-2 (December 10, 1992);

- a water level difference of 1.7 feet and a gradient of 0.07 feet/foot was measured (towards the Production Area) on Day 12 of the 30-Day Constant Rate Test after about 4 inches of rainfall fell during the period of December 11 through 13, 1992;

- a water level difference of 0.4 feet and a gradient of 0.02 feet/foot was measured (towards the Production Area) on Day 24 of 30-Day Constant Rate Test, about 9 days after the rainfall event (December 24, 1992).

This same effect was seen in the two other locations (P-35S/MW-31S and P-1S/MW-30S) where the difference in water level elevations and the gradient across the bulkhead was measured. The required gradient reversal can be maintained during and directly after a rainfall event, there is no need to adjust the drawdown levels by increasing the pumping rates from the recovery wells. OK

3.2.2 Performance Monitoring

Performance monitoring for the groundwater recovery system will consist of monitoring water levels, to evaluate groundwater gradient reversal. Chemical monitoring will also be performed as part of the performance monitoring program. Water levels will be measured to evaluate groundwater gradient reversal and changes in groundwater elevations. Specifically, the program will consist of the following:

- Monitoring of wells MW-10S and MW-10D (Figure 3-1) on a continuous basis using the data logging function of the programmable loop controller (PLC) to measure background water levels. This data will be evaluated on a periodic basis (e.g. monthly) to compare background water level changes with changes that occur due to the pumping of the recovery wells.

- Monitoring of the differential in water level elevations between monitoring points on both sides of the bulkhead to determine whether the required gradient reversal has been achieved. Monitoring will be conducted at P-35S/MW-31S, P-1S/MW-30S, P-37S/MW-29S using the data logging function of the PLC. The differential from these measurements will be used to automatically change the pumping rates to control drawdown (criteria presented later in this section).

- Monitoring of wells/piezometers near the bulkhead will be performed to determine if the cones of influence from the recovery wells produce the drawdown required to reverse the gradient. This monitoring will be

IF MEASURE HEAD

MONTHLY (SEE PG. 7 OF ORDER) MOD

Comment #2

STATE THIS TIMEFRAME. SHOULD BE MORE FREQUENT DURING SYSTEM START-UP UNTIL EQUILIBRIUM IS REACHED.

conducted at MW-2S, P-2D, P-36S, P-38S, and MW-3S using pressure transducers connected to the PLCs. These data will be evaluated on a periodic basis to determine whether the performance criteria (Section 3.2.1) have been met. These data will be compared to the groundwater elevation measured in the river well closest to that monitoring point. If the drawdown at these locations is not sufficient to reverse the gradient, higher recovery well pumping rates or additional recovery wells may be required.

- Manual water level elevations will continue to be measured monthly. √

The hydraulic gradient will be monitored and maintained automatically (and on a continuous basis) by the PLC. Hydraulic gradients will be controlled through the pumping rates of the recovery wells. When more drawdown is required to maintain the hydraulic gradient towards the Production Area, due to seasonal or other changes in water level, pumping rates will be increased. Pumping rate increases will be performed by increasing the opening on the control valve from the pump discharge line. Increasing the valve opening will be done automatically when the differential in the water levels between the Production Area piezometer (i.e. P-35S, P-1S, or P-37S) and the corresponding in-river well (i.e. MW-31S, MW-30S, or MW-29S) indicates that a hydraulic gradient toward the river is occurring. Pumping rate changes will be programmed to occur when the water level elevation in the Production Area wells is 0.1 feet or greater than the corresponding elevation in the river-well for a period of at least 48 hours, thus minimizing the number of times pumping rate changes will be required without compromising the objectives of the groundwater capture system.

SHOULD USE OTHER MONITORING LOCATIONS AS WELL? Comment 01

Groundwater samples will be analyzed during stabilization to evaluate changes in groundwater chemistry that occur due to pumping. The following sampling program is proposed:

- Two rounds of groundwater sampling will be performed as part of the Phase II RCRA Facility Investigation, after the groundwater capture system is operational. This sampling, while part of the Phase II work, will be used to evaluate constituent changes over the first year of operation. Each sample will be analyzed for Appendix IX compounds, fingerprint compounds, and major and minor ions. EVALUATE TRENDS OK

- Quarterly sampling of the recovery wells will be performed to evaluate changes in groundwater chemistry and influent constituent concentrations to the pretreatment system. These samples will be analyzed for Target Compound List Volatile Organic Compounds (TCL VOCs) and total iron and manganese. OK

OK

OK AND/OR OTHER WELLS SINCE RECOVERY WELLS HAVE GREATER DILUTION DUE TO LENGTH OF SCREEN

SEE PG. 7 OF ORDER MOO

Comment #3

- Semi-annual sampling (after year 2) of monitoring wells MW-1S, MW-2S, P-35S, P-36S, and P-37S will be performed to evaluate chemical changes in the shallow groundwater in the Production Area. The samples will be analyzed for TCL VOCs.

MORE LOCATIONS & EVALUATE THE EFFECT ON

3.3 GROUNDWATER PRETREATMENT SYSTEM

The objective of the groundwater pretreatment system is to remove inorganic and organic consistuents from the extracted groundwater. The design of the groundwater pretreatment system was based on data obtained during the bence-scale testing program and the on-site pilot pretreatment program discussed in the Stabilization Investigation Report and Design Concepts Proposal (May, 1993). As designed, the groundwater pretreatment system contains two components; aqueous-phase treatment and vapor-phase treatment.

3.3.1 Aqueous-Phase Treatment - Performance Standards

Groundwater from both the groundwater recovery system and the SVE system will be conveyed to the pretreatment system via an above-grade forcemain. Following equalization, metals oxidation, flocculation/clarification, sand filtration, air stripping and activated carbon adsorption, the groundwater will be discharged to the City of Cranston POTW via an existing sanitary sewer connection. For the aqueous-phase treatment portion of the groundwater pretreatment system, the City of Cranston has developed and determined the required performance standards (i.e., effluent quality standards) to ensure the overall protection of the environment and minimize any potential impacts on human health. The City of Cranston performance standards for the aqueous-phase treatment portion of the groundwater pretreatment system are presented in Table 3-2.

3.3.2 Aqueous-Phase Treatment - Performance Monitoring

Effluent from the groundwater pretreatment system will be conveyed to the City of Cranston sanitary sewer and eventually the POTW. Prior to entering the sanitary sewer, the effluent from the aqueous-phase treatment portion of the pretreatment system will be sampled using a Isco-type composite sampler. In accordance with the City of Cranston's Self-Monitoring Report requirements, 24-hour effluent composite samples will be collected twice per month (on the first and third week) for the first six (6) months of system operation. Grab samples for VOCs will also be collected on the first and third week of every month. Analysis of the effluent will be performed to ensure that the performance standards noted in Section 3.3.1 are obtained. After about six months of operation, the City of Cranston may reduce the required sampling period from twice per month to bi-monthly (once every two months). Eventually, the required performance sampling/reporting effort may be reduced to quarterly by the City of Cranston.

3.3.3 Vapor-Phase Treatment - Performance Standards

To facilitate the removal of VOCs from the groundwater, the groundwater pretreatment system design includes air stripping followed by vapor-phase activated carbon adsorption. Following treatment, the discharge from the vapor-phase activated carbon will be exhausted to the atmosphere. The performance standards proposed for the vapor-phase portion of the groundwater pretreatment system are the standards developed and established by the Rhode Island Department of Environmental Management (RIDEM) - Division of Air and Hazardous Materials. These maximum allowable emission rates have been established by RIDEM to ensure the overall protection of the environment and to minimize any potential impacts to human health. The RIDEM performance standards for the vapor-phase treatment portion of the groundwater pretreatment system are presented in Table 3-3.

3.3.4 Vapor-Phase Treatment - Performance Monitoring

The discharge from the vapor-phase activated carbon adsorption system will be exhausted to the atmosphere after treatment. In accordance with the reporting requirements of RIDEM - Division of Air and Hazardous Materials, sampling of the vapor-phase activated carbon exhaust will be performed at the beginning of system operation to demonstrate compliance with the performance standards noted in Section 3.3.3. Following start-up, sampling and reporting to RIDEM will be performed annually.

NO QUARTERLY

IF GW CONTAMINANT LOADING TO THE SYSTEM IS INCREASED BASED ON G.W. SAMPLING OF THE RECOVERY WELLS, SAMPLING OF VAPOR-PHASE ACTIVATED CARBON EXHAUST WILL BE PERFORMED.

3.4 SOIL VAPOR EXTRACTION SYSTEM

3.4.1 Performance Standards

The design of the stabilization system for SWMU-11 includes both soil vapor and groundwater extraction to remove constituents from the saturated and unsaturated zones. The performance of the SVE and groundwater extraction systems in SWMU-11 are based on their ability to reduce contaminant concentrations (in the soil and groundwater) and to limit migration within the footprint of the former Building No. 11 foundation (as shown by the dashed line on Figure ~~2-1~~ 2-2). The SVE system performance will be based on maintaining a measured vacuum beyond the former foundation area. The vacuum will be measured in the monitoring wells presented in Section 2.4.1.

Comment #4

HOW WILL IT BE MEASURED

The performance of the groundwater extraction system for SWMU-11 will be based strictly on the mass of contaminates removed from the area. There will be no hydraulic performance criteria proposed for the SWMU-11 groundwater extraction system. However, drawdown will periodically be measured in the extraction and observation wells (Figure ~~2-1~~ 2-4) to evaluate the effect on the system.

Groundwater extracted by the SVE system will be conveyed to the groundwater pretreatment system for treatment prior to discharge to the sanitary sewer and POTW. Performance standards for the aqueous-phase portion of the groundwater treatment system are presented in Table 3-2.

Soil vapors extracted during stabilization activities in of SWMU-11 will be treated by a thermal/catalytic oxidizer prior to discharge to the atmosphere. The performance standards proposed for the soil vapor portion of the SVE system will be the standards developed and established by RIDEM's - Division of Air and Hazardous Materials. These maximum allowable emission rates have been established to ensure the overall protection of the environment and to minimize any potential impacts to human health. The RIDEM performance standards for the soil vapor extraction portion of the SVE system are identical to those performance standards presented for the vapor-phase portion of the groundwater pretreatment system (presented in Section 3.3.3).

3.4.2 Performance Monitoring

Performance monitoring for the SVE system will be in accordance with Sections 3.3.2 and 3.3.4.

3.5 SUMMARY

This chapter described the performance standards and the performance monitoring for the *groundwater capture, groundwater pretreatment* and *soil vapor extraction* (SVE) systems.

<u>Groundwater Capture System</u>

The groundwater capture system includes two to four pumping wells to reverse the hydraulic gradient at the bulkhead from its present direction towards the Pawtuxet River. Representative hydraulic gradients were determined from well and/or piezometer couplets that were located on both sides of the bulkhead. The minimum drawdown goals for the groundwater capture system are 0.5 feet of drawdown in the southern portion of the bulkhead; 1.0 feet of drawdown in the center portion of the bulkhead; and 1.7 feet of drawdown in the northern portion of the bulkhead. The proposed drawdown goals are based on the average water level difference across the bulkhead and include a 20 percent safety factor.

The gradient across the bulkhead is not changed by precipitation, even under very wet conditions. As a result, additional pumping during a rainfall event to compensate for the increased water level elevations is not required.

Performance monitoring for the groundwater recovery system will consist of water level monitoring. Monitoring of wells MW-10S and MW-10D will be performed on a continuous basis using the PLC. Monitoring of the differential in water level elevations between monitoring points on both sides of the bulkhead will be performed to determine whether the required gradient reversal has been achieved. Monitoring will be conducted at P-35S/MW-31S, P-1S/MW-30S, P-37S/MW-29S. Monitoring of wells/piezometers near the bulkhead will be performed to determine if the cones of influence from the recovery wells produce the drawdown required to reverse the gradient. Water level elevations will continue to be measured monthly.

Chemical monitoring will be performed to evaluate changes in groundwater chemistry that occur due to pumping. Chemical sampling will consist of two rounds of sampling in each Production Area well will be performed as part of the Phase II RCRA Facility Investigation, quarterly sampling of the groundwater from the recovery wells and semi-annual sampling.

<u>Groundwater Pretreatment System</u>

The groundwater pretreatment system is designed to remove constituents from the groundwater extracted from the Production Area. The groundwater pretreatment system contains two components; aqueous-phase treatment and vapor-phase treatment. Groundwater from both the groundwater recovery system and the SVE system will be conveyed to the pretreatment system. Following pretreatment, the groundwater will be discharged to the City of Cranston POTW. For the aqueous-phase treatment portion of the groundwater pretreatment system, the City of Cranston POTW discharge standards will be met. The discharge from the vapor-phase activated carbon system will be exhausted to the atmosphere. The performance standards proposed for the vapor-phase portion of the groundwater pretreatment system are the maximum allowable emission standards developed and established by RIDEM - Division of Air and Hazardous Materials.

In accordance with the City of Cranston's Self-Monitoring Report requirements, 24-hour effluent composite samples will be collected twice per month for the first six (6) months of system operation. Grab samples for VOCs will also be collected on the first and third week of every month. After about six months of operation, the City of Cranston may reduce the required sampling period from twice per month to bi-monthly (once every two months).

In accordance with the reporting requirements of RIDEM - Division of Air and Hazardous Materials, performance sampling of the vapor-phase activated carbon exhaust will be performed at the beginning of system operation and then annually.

<u>Soil Vapor Extraction (SVE) System</u>

The design of the stabilization system for SWMU-11 includes both soil vapor and groundwater extraction to remove constituents from the saturated/ and unsaturated zones. Groundwater extracted by the SVE system will be conveyed to the on-site groundwater pretreatment system for treatment prior to discharge to the sanitary sewer and POTW.

The performance of the SVE system will be based on its ability to reduce contaminant concentrations. The performance will be evaluated by measuring the vacuum in the proposed observation wells. The performance of the groundwater extraction system will be based strictly on the mass of contaminants removed.

Soil vapors extracted during stabilization of SWMU-11 will be treated using a thermal/catalytic oxidizer prior to discharge to the atmosphere. The performance standards proposed for the soil vapor portion of the SVE system will be the maximum allowable emission standards developed by RIDEM's - Division of Air and Hazardous Materials.

The next chapter discusses the confirmatory sampling plan and shut-down criteria for the stabilization action.

TABLE 3-1
DIFFERENCES IN WATER LEVEL ELEVATIONS AND
HYDRAULIC GRADIENTS ACROSS THE BULKHEAD

Monitoring Point	Reference Elevation (ft MSL)	DEPTH TO WATER MEASUREMENTS (feet below reference elevation) 11/30/92	2/3/93	2/25/93	3/31/93	4/29/93	5/27/93	6/30/93	7/29/93	8/30/93
P-35S	15.32	5.97	5.93	5.51	3.46	5.02	6.86	7.24	6.99	7.35
~~P-2D~~	~~16.00~~	~~6.77~~	~~6.59~~	~~6.14~~	~~3.80~~	~~5.65~~	~~7.24~~	~~7.66~~	~~7.49~~	~~7.10~~
MW-31S	16.27	6.97	6.79	6.46	4.34	6.42	8.04	9.70	8.18	8.45
~~MW-31D~~	~~16.21~~	~~6.97~~	~~6.96~~	~~6.52~~	~~4.30~~	~~6.43~~	~~8.24~~	~~8.38~~	~~7.99~~	~~8.30~~
~~P-1S~~	~~16.41~~	~~6.55~~	~~7.25~~	~~6.78~~	~~4.70~~	~~7.95~~	~~7.50~~	~~7.96~~	~~7.41~~	~~8.18~~
P-1D	16.33	7.20	8.15	7.81	7.30	6.92	7.20	7.64	7.91	8.00
~~MW-30S~~	~~16.70~~	~~8.31~~	~~8.37~~	~~7.87~~	~~5.20~~	~~7.73~~	~~9.40~~	~~8.40~~	~~9.40~~	~~9.68~~
MW-30D	16.67	8.27	8.20	7.93	5.22	7.76	9.50	9.70	9.42	9.66
P-37S	15.69	5.73	6.23	5.81	3.41	5.21	6.50	6.90	6.70	7.00
MW-29S	16.66	8.15	8.21	7.97	5.21	7.80	8.50	9.78	9.36	9.71

Monitoring Point	Reference Elevation (ft MSL)	WATER LEVEL ELEVATIONS (feet Mean Sea Level) 11/30/92	2/3/93	2/25/93	3/31/93	4/29/93	5/27/93	6/30/93	7/29/93	8/30/93
P-35S	15.32	9.35	9.39	9.81	11.86	10.30	8.46	8.08	8.33	7.97
P-2D	16.00	9.23	9.41	9.86	12.20	10.35	8.76	8.34	8.51	8.90
MW-31S	16.27	9.30	9.48	9.81	11.93	9.85	8.23	6.57	8.09	7.82
MW-31D	16.21	9.24	9.25	9.69	11.91	9.78	7.97	7.83	8.22	7.91
P-1S	16.41	9.86	9.16	9.63	11.71	8.46	8.91	8.45	9.00	8.23
P-1D	16.33	9.13	8.18	8.52	9.03	9.41	9.13	8.69	8.42	8.33
MW-30S	16.70	8.39	8.33	8.83	11.50	8.97	7.30	8.30	7.30	7.02
MW-30D	16.67	8.40	8.47	8.74	11.45	8.91	7.17	6.97	7.25	7.01
P-37S	15.69	9.96	9.46	9.88	12.28	10.48	9.19	8.79	8.99	8.69
MW-29S	16.66	8.51	8.45	8.69	11.45	8.86	8.16	6.88	7.30	6.95

Monitoring Point	Distance Between Points (ft)	DIFFERENCE IN WATER LEVEL ELEVATIONS ACROSS THE BULKHEAD (feet) 11/30/93	2/3/93	2/25/93	3/31/93	4/29/93	5/27/93	6/30/93	7/29/93	8/30/93	Average Difference (ft)	Average Gradient (feet/foot)
P-35S/MW-31S	17	-0.05	0.09	0.00	0.07	-0.45	-0.23	-1.51	-0.24	-0.15	-0.27	-0.02
P-2D/MW-31D	65	0.01	-0.16	-0.17	-0.29	-0.57	-0.79	-0.51	-0.29	-0.99	-0.42	-0.01
P-1S/MW-30S	30	-1.47	-0.83	-0.80	-0.21	0.51	-1.61	-0.15	-1.70	-1.21	-0.83	-0.03
P-1D/MW-30D	33	-0.73	0.29	0.22	2.42	-0.50	-1.96	-1.72	-1.17	-1.32	-0.50	-0.02
P-37S/MW-29S	23	-1.45	-1.01	-1.19	-0.83	-1.62	-1.03	-1.91	-1.69	-1.74	-1.39	-0.06
		negative numbers indicate flow potential into river										

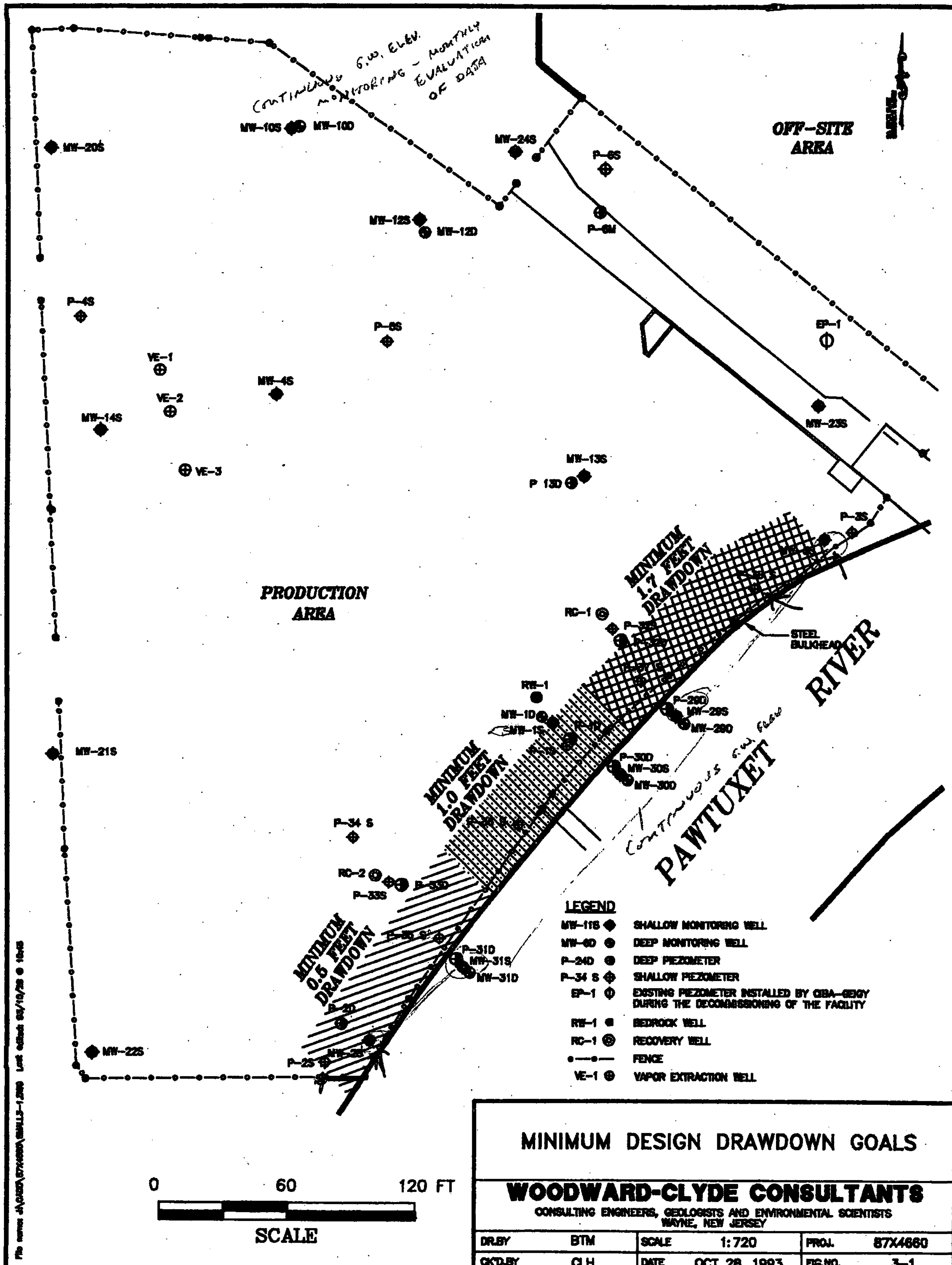
Table 3-2
Proposed Performance Standards
Stabilization Action - Cranston, Rhode Island
Groundwater Pretreatment System
Aqueous-Phase Treatment

Parameter	Effluent Concentration (mg/l)
Antimony (total)	0.05
Arsenic (total)	0.1
Beryllium (total)	0.005
Boron (total)	1.0
Cadmium (total)	0.04
Chromium (total)	0.4
Copper (total)	1.0
Cyanide (total)	0.3
Iron (total)	2.0
Lead (total)	0.3
Manganese (total)	2.0
Mercury (total)	0.005
Nickel (total)	0.7
Phenols (total)	1.0
Selenium (total)	0.01
Silver (total)	0.1
Thallium (total)	0.005
Zinc (total)	1.0
Total Toxic Organics	2.13
Oil and Grease	25 Mineral/Petroleum Origin 100 Animal/Vegetable Origin
pH	5.5 to 9.5 units

Table 3-3 Proposed Performance Standards Stabilization Action - Cranston, Rhode Island Groundwater Pretreatment System *Vapor-Phase Treatment*	
Parameter	**Maximum Emission Rate (lb/hr)**
Acrylonitrile	0.004
Aniline	0.04
O-Anisidine	0.001
Antimony & Antimony Compounds	1.14
Arsenic & Arsenic Compounds	0.0
Benzene	0.005
Benzidine	0.0
Benzotrichloride	0.0
Benzyl Chloride	0.005
Cadmium & Cadmium Compounds	0.0
Carbon Tetrachloride	0.001
Chloroform	0.002
Chromium & Chromium Compounds	0.0
3,3'-dichlorobenzidine	0.0001
Dioctyl Phthalate	0.03
Diphenyl	0.02
Diphenyl Amine	1.14
Epichlorohydrin	0.04
Ethylene Dichloride	0.002
Ethylene Oxide	0.0005
Hydrazine	0.0
Hydrogen Chloride	1.14
Hydrogen Fluoride	0.1
Lead	1.14
Manganese & Manganese Compounds	0.01

Table 3-3
Proposed Performance Standards
Stabilization Action - Cranston, Rhode Island
Groundwater Pretreatment System
Vapor-Phase Treatment

Parameter	Maximum Emission Rate (lb/hr)
Methyl Cellosolve	1.14
Methylene Biphenyl Iscyante (MDI)	0.003
4,4'-Methylene bis(2-chloroaniliine)	0.05
Methylene Chloride	0.01
Nickel & Nickel Compounds	0.0001
5-Nitro (o-anisidine)	0.004
2-Nitropropane	0.01
Perchloroethylene	0.002
Styrene	1.14
Toluene	1.14
Toluene-2,4 Diisocyanate (TDI)	0.001
O-Toluidene	0.002
1,1,2 Trichloroethane	0.3
Trichloroethylene	0.02
Triethylamine	1.14
Xylene	1.14
Other Contaminants	10



CONTINUOUS G.W. ELEV. MONITORING – MONTHLY EVALUATION OF DATA
OFF-SITE AREA
PRODUCTION AREA
PAWTUXET RIVER
MINIMUM 1.7 FEET DRAWDOWN
MINIMUM 1.0 FEET DRAWDOWN
MINIMUM 0.5 FEET DRAWDOWN
STEEL BULKHEAD
CONTINUOUS G.W. FLOW
MW-20S
MW-10S
MW-10D
MW-24S
P-6S
P-6M
MW-12S
MW-12D
P-4S
P-8S
EP-1
VE-1
VE-2
VE-3
MW-4S
MW-14S
MW-23S
MW-13S
P 13D
P-2S
RC-1
RW-1
MW-1D
MW-1S
P-29D
MW-29S
MW-29D
P-30D
MW-30S
MW-30D
MW-21S
P-34 S
RC-2
P-33S
P-33D
P-31D
MW-31S
MW-31D
MW-22S
P-22S
LEGEND
MW-11S SHALLOW MONITORING WELL
MW-6D DEEP MONITORING WELL
P-24D DEEP PIEZOMETER
P-34 S SHALLOW PIEZOMETER
EP-1 EXISTING PIEZOMETER INSTALLED BY CIBA-GEIGY DURING THE DECOMMISSIONING OF THE FACILITY
RW-1 BEDROCK WELL
RC-1 RECOVERY WELL
FENCE
VE-1 VAPOR EXTRACTION WELL
0
60
120 FT
SCALE
MINIMUM DESIGN DRAWDOWN GOALS
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY
DR.BY BTM
SCALE 1:720
PROJ. 87X4660
CK'D.BY CLH
DATE OCT 28, 1993
FIG.NO. 3-1

SECTION 4

4.0
SHUT-DOWN CRITERIA
CONFIRMATORY SAMPLING PLANS

4.1 OVERVIEW

This chapter presents the shut-down criteria and confirmatory sampling plans for the *groundwater capture system*, and the *soil vapor extraction (SVE) system*. The shut-down criteria for the *groundwater pretreatment system* also is presented here.

Shut-down criteria and confirmatory sampling plans for the three stabilization systems are discussed in three sections:

- Section 4.2 presents the shut-down criteria and confirmatory sampling plan for the groundwater capture system;
- Section 4.3 presents the shut-down criteria for the pretreatment system (aqueous and vapor phase); and
- Section 4.4 presents the shut-down criteria and confirmatory sampling plan for the soil vapor extraction system.

4.2 GROUNDWATER CAPTURE SYSTEM

The groundwater capture system is designed to reverse the hydraulic gradient at the bulkhead. The shut-down criteria and confirmatory sampling for the groundwater capture system is presented here. The shut-down criteria will consist of chemical monitoring to evaluate changes in groundwater chemistry. Confirmatory sampling will be performed to ensure that the shut-down criteria have been met.

4.2.1 Shut-Down Criteria

To develop the shut-down criteria for the groundwater capture system, Media Protection Standards will be required. These standards will be developed during Phase II of the RCRA Facility Investigation. Shut-down criteria will be based on the concentrations of constituents monitored in the recovery wells and in selected monitoring wells and piezometers (Section 4.2.2). If the concentrations of constituents are lower than the Media Protection Standards during four consecutive sampling events, then shut-down will be evaluated.

OK

WHAT TIME FRAME AND WHERE LOCATED?

Cmnt #5

Shut-down of the recovery wells may result in an increase in constituent concentrations in groundwater because the constituents that are adsorbed to the soil above the drawdown water level may become dissolved in groundwater following recovery. Testing will be performed shortly after the full-scale groundwater capture system is started to determine whether a flush/surge test will be beneficial in reducing constituent concentrations that might increase as a result of shutting down the recovery wells.

4.2.2 Confirmatory Sampling Plan

Comment #6

MW-3S & P-38S ADDED

Confirmatory sampling for the groundwater capture system will occur after the shut-down criteria noted above has been satisfied. Groundwater in the recovery wells and in monitoring wells MW-1S, MW-2S and piezometers P-35S, P-36S and P-37S will be sampled once after the shut-down of the groundwater capture system occurs and then on a semi-annual basis for a period of at least one year after shutdown.

WHEN? (GIVE TIME TO REACH EQUILIBRIUM

FOR WHAT

? MORE OFTEN

4.3 GROUNDWATER PRETREATMENT SYSTEM

The objective of the groundwater pretreatment system is to remove inorganic and organic consistuents from the extracted groundwater during stabilization. The shut-down criteria for the pretreatment system is presented here.

4.3.1 Shut-Down Criteria

The groundwater pretreatment system will be operated as long as groundwater from the groundwater capture system and SVE system is being pumped and the performance standards for the groundwater pretreatment system are being met. However, as with any treatment system, shut-down periods for equipment replacement, maintenance and emergencies are anticipated during operation of the system. Shut-down periods for regular equipment maintenance or re-calibration could run from 1 to 2 weeks, possibly longer, depending on the type of maintenance or re-calibration required. Major equipment failure/replacement could require a system shut-down of 6 to 10 weeks, depending on the availability, type and installation procedures for the equipment. Catastrophic system failures could require shut-down periods in excess of 10 weeks. Based on the preliminary estimates presented in the Stabilization Investigation Report and Design Concepts Proposal, the travel time beyond the capture zone of the recovery wells in the groundwater capture system was determined to be at least several months. As a result, shut-down periods such as those noted above, should not impact achieving the stabilization objectives.

4.4 SOIL VAPOR EXTRACTION SYSTEM

The design of the stabilization system for SWMU-11 includes both soil vapor and groundwater extraction to remove constituents from the saturated and unsaturated zones. Groundwater extracted by the SVE system will be conveyed to the groundwater pretreatment system for treatment prior to discharge. Soil vapors extracted during stabilization of SWMU-11 will be treated using a thermal/catalytic oxidizer prior to discharge to the atmosphere.

4.4.1 Shut-Down Criteria

The SVE system will be operated until either 1) The concentrations of VOCs in the extracted soil vapor remain statistically flat (asymptotic as determined by data regression) for a six month period based on monthly soil vapor analytical data or 2) The concentrations of VOCs in the extracted groundwater in each of the extraction wells remain statistically flat (as determined by data regression) for at least four quarters based on quarterly groundwater monitoring analytical data.

INCONSISTENT

If concentrations of VOCs in the soil vapor become statistically flat, but the concentrations of VOCs in the groundwater do not, the SVE system will be shutdown. Groundwater will continue to be pumped to the pretreatment system ~~until the~~ VOC concentrations remain statistically flat for a six-month period.

Comment #7

— DO FLUSH/SURGE —

4.4.2 Confirmatory Sampling Plan

Confirmatory sampling for the SVE system will occur after the shut-down criteria noted above has been satisfied. Confirmatory sampling for the SVE system will consist of soil sampling at selected locations within the SWMU-11 area. About 20 soil borings will be advanced within the SWMU-11 area to deter~~mine the~~ concentrations and locations of VOCs in the soils. — AND @ WHAT DEPTH ? ~~WHAT CONSTITUENTS~~

Comment #8 OTHER INDICATORS ?

4.5 SUMMARY

This chapter described the shut-down criteria and confirmatory sampling plans for the *groundwater capture, groundwater pretreatment* and *soil vapor extraction* (SVE) systems.

<u>Groundwater Capture System</u>

To develop the shut-down criteria for the groundwater capture system, Media Protection Standards will be required. These standards will be developed during Phase II of the RCRA Facility Investigation. If concentrations of the constituents are lower than the Media Protection Standards detected during sampling events, shut-down of the groundwater capture system will be evaluated.

Confirmatory sampling for the groundwater recovery system will occur after the shut-down criteria for the groundwater capture system has been satisfied. Groundwater in the recovery wells and in wells MW-1S, MW-2S, P-35S, P-36S and P-37S will be sampled after shut-down and then on a semi-annual basis.

<u>Groundwater Pretreatment System</u>

The groundwater pretreatment system will be operated as long as groundwater from the groundwater capture system and SVE system is being pumped and the performance standards for the groundwater pretreatment system are being met. Shut-down periods for regular equipment maintenance or re-calibration could run from 1 to 2 weeks possibly longer depending on the type of maintenance or re-calibration required. Major equipment failure/replacement could require a system shut-down of 6 to 10 weeks, depending on the availability, type and installation procedures for the equipment. Catastrophic system failures could require shut-down periods in excess of 10 weeks.

Soil Vapor Extraction (SVE) System

The SVE system will be operated until either the concentrations of VOCs in the extracted soil vapor remain statistically flat (asymptotic as determined by data regression) for a six month period based on monthly soil vapor analytical data or until the VOC concentrations remain statistically flat for a period of four quarters.

Confirmatory sampling for the SVE system will occur after the shut-down criteria noted above has been satisfied. Confirmatory sampling for the SVE system will consist of soil sampling at selected locations within the SWMU-11 area.

The next chapter discusses the project management plan for the stabilization action.

SECTION 5

5.1 OVERVIEW

Project management ensures that all work necessary for the stabilization program will be completed in a timely fashion. A project management plan for the RCRA Facility Investigation at the site was presented in Volume 1 of the RCRA Facility Investigation Proposal. That plan described the organization of the project and identified the tasks to be accomplished (including deliverable reports) as well as the schedule for completing those tasks. The project management plan was updated in Chapter 18 of the Phase I Interim Report and Phase II Proposal (submitted in November 1991), in Chapter 7 of the Phase II Pawtuxet River Proposal (submitted in January 1992), in Chapter 6 of the Stabilization Work Plan (approved in December 1992), and in the Stabilization Investigation Report and Design Concepts Proposal (submitted in May 1993).

This chapter also updates (not replaces) the project management plan; it addresses project management issues only for the activities associated with the stabilization program, including:

- the project organization for the stabilization program (Section 5.2);
- the schedule for the stabilization program (Section 5.3); and
- contingency plans and other considerations for the stabilization program (Section 5.4).

A summary concludes this chapter (Section 5.5).

5.2 PROJECT ORGANIZATION

The project organization for this stabilization program ultimately reports to the USEPA and centers on the CIBA-GEIGY Project Coordinator who is responsible for 1) coordinating the interaction among all project participants, and 2) ensuring that the objectives of the stabilization program are met. The organization structure for the stabilization program, shown in Figure 5-1, is basically the same as that presented in Figure 6-1 of the Stabilization Investigation Report and Design Concepts Proposal.

5.3 SCHEDULE

The stabilization program is on a separate schedule from the Phase II activities for the RCRA Facility Investigation at the site. This section discusses three aspects of the remaining schedule for the stabilization program:

- the design phase of the program;
- the implementation phase of the program; and
- the reports needed for the stabilization program.

5.3.1 Design Phase

Figure 5-2 shows the schedule for developing and submitting the Final Stabilization Design Documents (FSDD) (the next major deliverable required in the design phase of the stabilization program). This schedule must be regarded as representing only preliminary estimates of target dates because the submittal date of the FSDD depends on when comments on the DSDD are received from the USEPA. The development of the FSDD will start after receiving comments from the USEPA on the Draft Stabilization Design Documents (DSDD).

The FSDD are scheduled currently to be delivered three months after receiving comments from the USEPA on the DSDD. In general, the activities for developing and submitting the FSDD will include the following:

- reviewing USEPA's comments on the DSDD;
- addressing USEPA's comments;
- drafting the FSDD;
- reviewing the FSDD;
- revising the FSDD; and
- producing and submitting the FSDD to the USEPA.

5.3.2 Implementation Phase

The implementation phase of the stabilization program will start thirty (30) days after comments are received from the USEPA on the FSDD and all required permits and approvals for construction have been granted. In general, the implementation phase of the stabilization action will include:

- advertisement of the stabilization action contract documents;
- evaluation of the bids;
- award of contract;
- procurement of equipment and construction;
- start-up and testing;
- operation and maintenance;
- monitoring; and
- preparation of future stabilization reports after the performance standards are met.

5.3.3 Stabilization Action Reports

During development of the FSDD and implementation of the stabilization action, information will continue to be delivered formally to the USEPA in Monthly Progress Reports and in major reports at key points during the stabilization program. This section discusses briefly the deliverables for each of these reporting mechanisms.

- Monthly Progress Reports - Activities performed as part of the Stabilization Action will continue to be discussed in the Monthly Progress Reports. These reports will be submitted on or before the 10th day of each month.

- Final Stabilization Design Documents (FSDD) - The proposed final design documents will be developed and delivered to the USEPA three months after receiving comments on the Draft Stabilization Design Documents (DSDD).

- Stabilization Reports - Delivered to the USEPA three months after the approved performance standards have been met in the Production Area.

5.4 CONTINGENCIES AND CONSIDERATIONS

Successful management and timely completion of this project depends on identifying two risk management procedures including:

- the contingencies that may arise and outlining plans to counter them; and

- critical success factors - those management issues that will "make or break" the successful and timely completion of the stabilization program.

5.4.1 Contingencies and Planned Responses

Five contingencies have been identified at this point for the stabilization program:

- permits to discharge pretreated groundwater from a full-scale groundwater capture and pretreatment system to the POTW may be refused or delayed;

- permits to discharge treated air from the full-scale groundwater pretreatment system (air stripper/vapor-phase activated carbon adsorption) may be refused or delayed;

- permits to discharge treated air from the full-scale soil vapor extraction system may be refused or delayed;

- other permits or approvals required for stabilization activities may be refused or delayed; and

- equipment procurement, delivery, and/or construction may be delayed.

These contingencies, and the plans for managing each, are discussed in this section. In addition, the assumptions for designing the stabilization measures also should be regarded as contingencies.

Groundwater Discharge Permits for Pretreatment System Refused or Delayed

Discharge of pretreated groundwater from full-scale pretreatment system to the Cranston POTW will require obtaining a new industrial discharge permit from the POTW. If unforeseen (or significant) delays are encountered in obtaining this permit from the POTW, then the schedule for subsequent activities in the stabilization program will be impacted.

Air Discharge Permits for Pretreatment System Refused or Delayed

Discharge of treated air from the full-scale groundwater pretreatment system (after air stripping and treatment with vapor-phase activated carbon adsorption) will require obtaining an air emission permit from RIDEM. If unforeseen (or significant) delays are encountered in obtaining this permit, then the schedule for implementing the stabilization action will be impacted.

Air Discharge Permits for Soil Vapor Extraction System Refused or Delayed

Discharge of treated air from the full-scale soil vapor extraction system will require obtaining separate air emission permit from RIDEM. If unforeseen (or significant) delays are encountered in obtaining this permit, then the schedule for implementing the stabilization action may be impacted.

Other Permits/Approvals Refused or Delayed

It is likely that a variety of other permits (e.g., construction permits) or approvals will need to be obtained for the stabilization program. Because the nature and number of such permits/approvals, the time required to obtain permits/approvals is not reflected in the schedule for the stabilization program. Every attempt will be made to minimize the routine delays encountered during permitting. However, any significant delays encountered in obtaining other permits/approvals will impact the schedule for the stabilization program.

Equipment Procurement, Delivery, and/or Construction Delayed

Process equipment for the full-scale groundwater pretreatment system and for the soil vapor extraction system will be ordered from manufacturers and delivered to the site; the systems will then be constructed on-site. It is likely that some of the equipment proposed will require a long-lead time to procure. To minimize the potential impact on the stabilization schedule, alternate sources of equipment will be identified during the design phase of the stabilization program. However, any significant delays encountered in equipment procurement, delivery, and/or construction will impact the schedule for the stabilization program.

<u>Assumptions for Designing the Stabilization Measures</u>

As mentioned, the general assumptions used for selecting potentially applicable technologies and in designing the stabilization measures also are regarded as contingencies:

- POTW acceptance of groundwater discharge - It is assumed that the necessary permits/approvals will be obtained, and that the necessary procedures will be established, so that the POTW will accept pretreated groundwater. As discussed earlier, delays or refusals in obtaining permits and/or approvals will impact the schedule for stabilization.

- Air stripper discharge will require treatment to meet air quality standards- It is assumed that vapors emitted by air stripping will require using control/treatment technologies to meet relevant RIDEM air quality standards.

- Groundwater will require treatment to discharge limits - It is assumed that groundwater extracted for hydraulic control will require using control/treatment technologies to meet the POTW discharge limits and non-hazardous TCLP criteria.

- Wells pumped will depend on field conditions - Field conditions may change before or during implementation of stabilization, so it is assumed that, if no response is observed at a well proposed for pumping, one or more new wells may need to be installed and tested.

- Constituent concentrations will increase - The conceptual designs are based on the concentrations of constituents detected during the stabilization investigation. It is assumed that the concentrations of these constituents will be higher in the groundwater recovered during stabilization pilot test.

- Trace constituents will not be problematic - During the stabilization pilot test, some constituents were detected only occasionally and, when detected, were detected in trace concentrations; it is assumed that those constituents will not be encountered at concentrations that affect the ability of the pretreatment system to meet the discharge limitations.

5.4.2 Critical Success Factors

Two critical success factors have been identified during Phase I and the stabilization investigation including:

- vendor-supplied equipment must be delivered on schedule; and
- contractor-performed construction must be completed on schedule.

This section discusses these critical success factors.

Vendor-Supplied Equipment Delivery

Reliable vendors must be identified for providing the equipment needed for the full-scale groundwater capture, pretreatment system and for the full-scale soil vapor extraction system. Contractual penalties (liquidated damages) may be used to help ensure that vendors will deliver the required equipment on schedule. Back-up vendors will be sought as well. However, if vendors supplying critical components of the full-scale systems fail to meet negotiated deadlines, the schedule for later stabilization phases could be impacted significantly.

Contractor-Performed Construction

Reliable contractors must be identified for constructing the full-scale groundwater capture, pretreatment system and the full-scale soil vapor extraction system. Contractual penalties (liquidated damages) may be used to help ensure that contractors will meet negotiated schedules. Back-up contractors may be sought as well. However, if contractors constructing critical components of the full-scale systems fail to meet negotiated deadlines, the schedule for later stabilization phases could be impacted significantly.

5.5 SUMMARY

This chapter addressed project management issues for the stabilization action currently in progress at the Cranston, Rhode Island site. The project direction for the stabilization action falls under the USEPA-Region I and the CIBA-GEIGY Project Coordinator. The current stabilization action and the Phase II activities for the RCRA Facility Investigation are on separate schedules. The schedule for the stabilization design phase is organized around the following group of activities:

1. Developing and submitting the FSDD, including drafting, reviewing, revising, and producing and submitting the report to the USEPA. After obtaining comments from the USEPA on the FSDD, the report will be revised (as needed).

2. Identifying contractors, including developing the construction standards, developing a list of potential contractors, and making a final selection of contractors, and making a final selection of contractors (including alternates, as needed).

Five specific contingencies have been identified for the stabilization program:

1. permits to discharge pretreated groundwater from a full-scale groundwater capture and pretreatment system to the POTW may be refused or delayed;

2. permits to discharge treated air from the full-scale groundwater pretreatment system may be refused or delayed;

3. permits to discharge treated air from the full-scale soil vapor extraction system (if needed) may be refused or delayed:

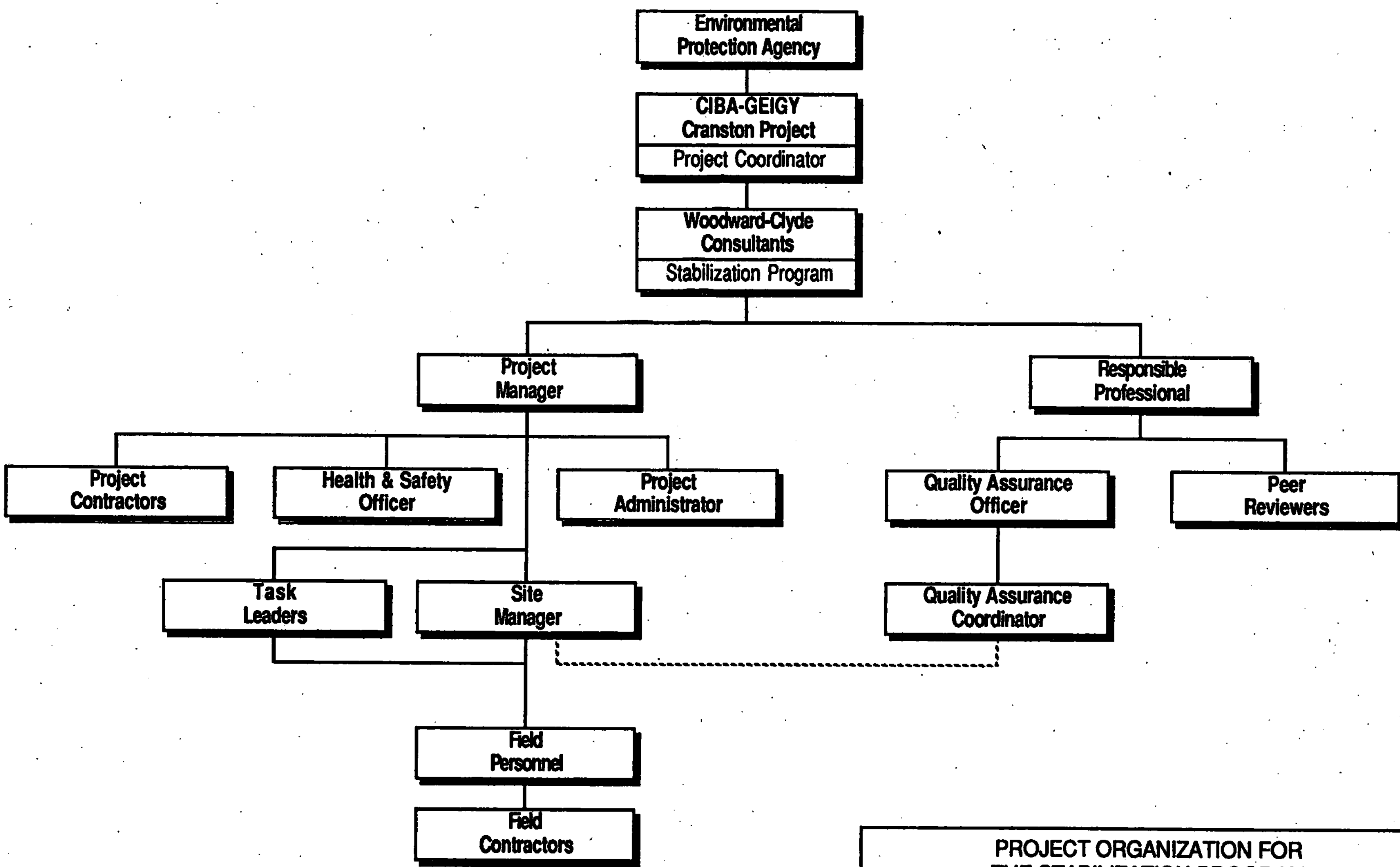
4. other permits or approvals required for stabilization activities may be refused or delayed; and

5. equipment procurement, delivery, and/or construction may be delayed.

Two critical success factors have been identified based on experience at the site:

1. vendor-supplied equipment must be delivered on schedule; and
2. vendor-performed construction must be completed on schedule.

Activities performed during the stabilization program will continue to be discussed in the Monthly Progress reports. The work performed in the design phase of the stabilization program will be discussed in the <u>Final Stabilization Design Documents</u> (delivered three months after receiving comments on the <u>Draft Stabilization Design Documents</u>). The <u>Stabilization Report</u>(s) will be prepared and submitted after the performance standards have been met for the stabilization actions in the Production Area.



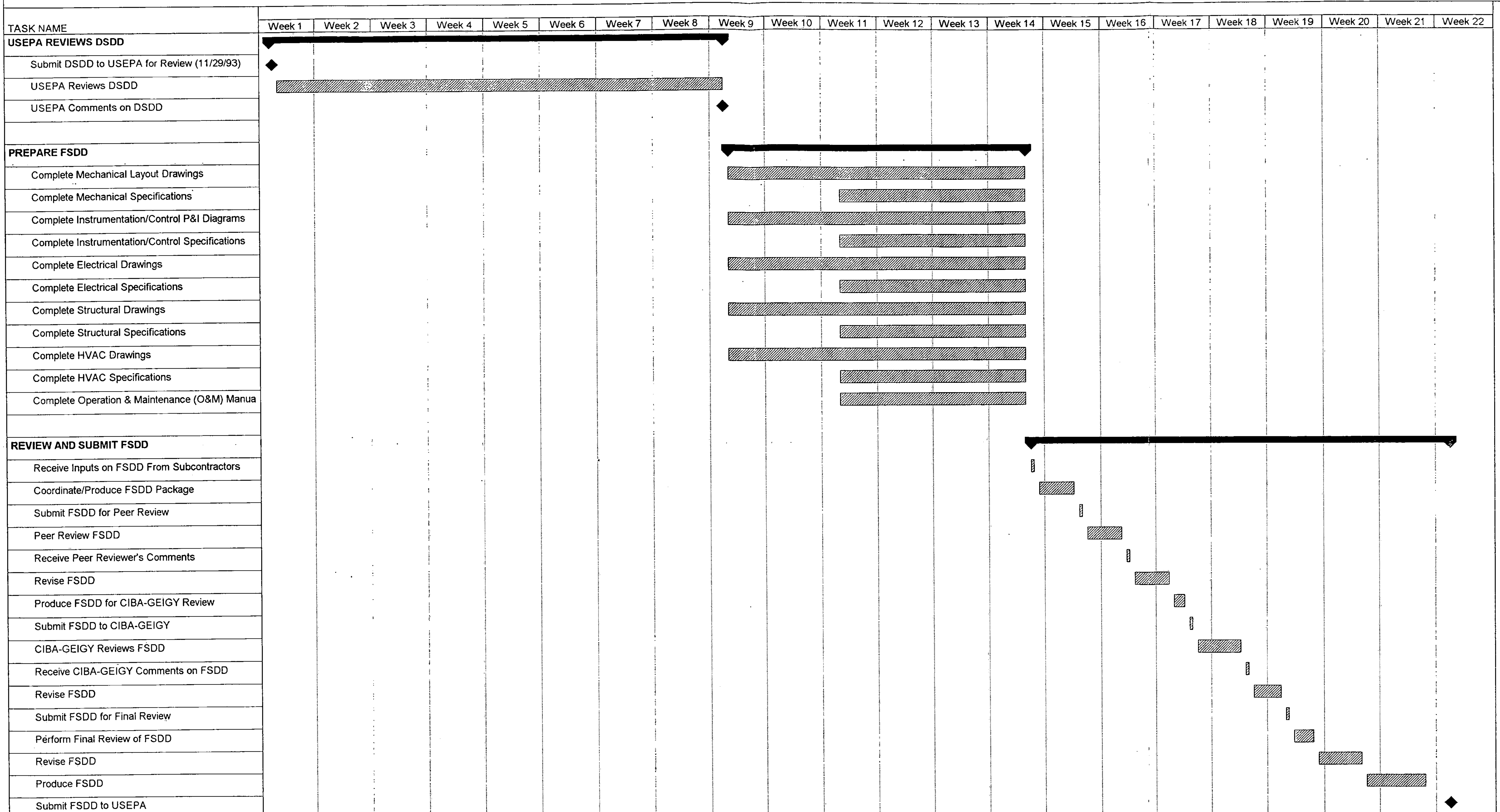
PROJECT ORGANIZATION FOR
THE STABILIZATION PROGRAM

WOODWARD-CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY: DWS	SCALE: NONE	PROJ. NO.: 87X4660
CK'D BY: MH	DATE: 15 JAN 1993	FIG. NO.: 5–1

DEVELOP FINAL STABILIZATION DESIGN DOCUMENTS (FSDD)
CIBA-GEIGY FACILITY
Cranston, Rhode Island



Project: 87X4660D
Date: 10/15/93

Critical   Milestone   Summary

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APPENDIX A

APPENDIX A
WELL CONSTRUCTION DETAILS:
GROUNDWATER CAPTURE SYSTEM
SOIL VAPOR EXTRACTION SYSTEM

This appendix presents the construction details of the groundwater recovery and soil vapor extraction wells that will be used for the full-scale groundwater capture and soil vapor extraction systems during stabilization. Two to four groundwater recovery wells will be installed to reverse the hydraulic gradient at the bulkhead (Figure A-1). The conceptual design of the groundwater capture system is based on the results of the aquifer testing that was performed in the Production Area as part of the stabilization field activities. The design criteria are presented in the Stabilization Investigation Report and Design Concepts Proposal (May 3, 1993).

The soil vapor extraction system will include seven wells that will recover soil vapor and/or groundwater at SWMU-11. The design of the soil vapor extraction system is based on its ability to remove constituent mass from the soil and groundwater in the SWMU-11 area.

Section A.1 presents the construction details for the groundwater recovery wells (RC-3 and RC-5) that were recently installed in the Production Area. Section A.2 presents the criteria for the installation of additional groundwater recovery wells and proposed construction details. Section A.3 presents the completion details for the soil vapor extraction wells.

A.1. EXISTING GROUNDWATER RECOVERY WELL CONSTRUCTION DETAILS

The conceptual design of the groundwater capture system presented in the Stabilization Investigation Report and Design Concepts Proposal included three recovery wells - RC-3, RC-4, and RC-5, located 15 to 25 feet from the bulkhead. Only two of these wells (RC-3 and RC-5) were installed during field activities conducted in July of 1993. The third recovery well (RC-4) will be installed (if needed) after aquifer testing of RC-3 and RC-5 is completed. Figure A-2 shows in cross-section the conceptual design of the three recovery wells proposed in the Stabilization Investigation Report and Design Concepts Proposal. Figure A-1 shows the location of this cross-section.

RC-3 and RC-5 were constructed in the manner described in Section 2.4.1 of the Stabilization Investigation Report and Design Concepts Proposal. Test boreholes were drilled at the selected well locations. Soil was sampled continuously from split-spoon samplers and logged; boring logs for these wells are presented in Attachment 1 of this appendix. Soil sampling and well installation activities were performed as described in the Quality Assurance Documents: Supplement.

Selected split-spoon soil samples were analyzed for grain size in the field using 3-inch sieves. Split-spoon samples were analyzed for grain size from 6 to 32 feet in RC-3 and from 4 to 16 feet, 24 to 26 feet, and 32 to 46 feet in RC-5. Selected samples from boring RC-5 were omitted from analysis if the grain size (determined visually) from that sample was similar to the preceding sample. The results of the grain size analyses are presented in Attachment 2 of this appendix.

Based on the results of the grain size analyses, the sand pack size and the screen slot size were selected for each well. Well construction details for RC-3 and RC-5 are presented in Figures A-3 and A-4.

Two screen intervals were constructed in RC-5 due to the low permeability Silt unit present between the upper Fill unit and the deeper Fine Sand unit at this location (about 16 to 30 feet below ground surface). With this unit cased off, it is possible to pump groundwater from both the more contaminated upper Fill unit and the deeper Fine Sand unit without introducing a downward pathway for contaminant migration.

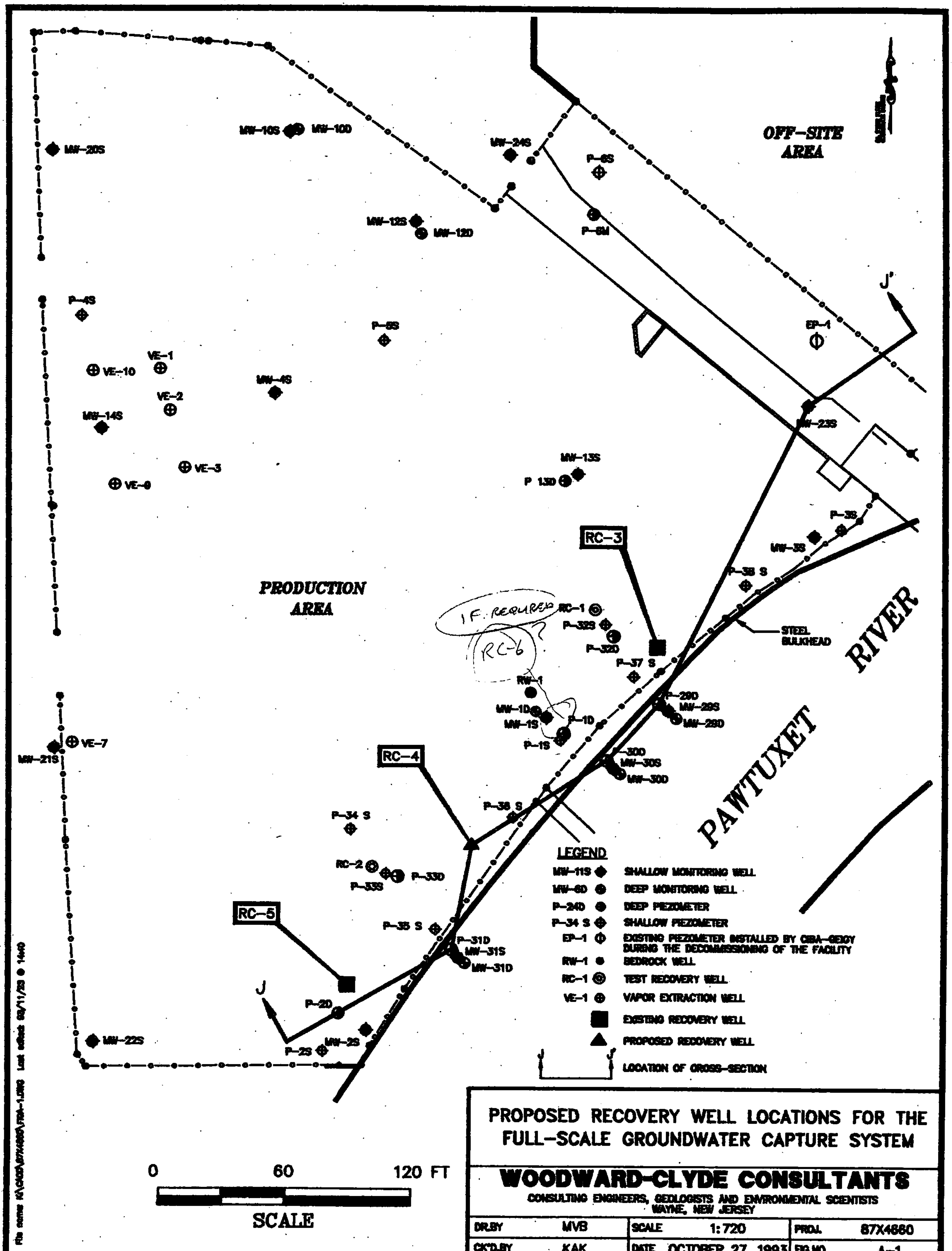
A.2 PROPOSED GROUNDWATER RECOVERY WELLS

Up to two additional well(s) may be required if the drawdown from RC-3 and RC-5 is not sufficient to reverse the hydraulic gradient at the required locations along the bulkhead. In the Stabilization Investigation Report and Design Concepts Proposal, a third well (RC-4) was proposed about midway between RC-3 and RC-5 (Figure A-1). The proposed construction of RC-4 is shown in Figure A-5. One other well (RC-6) located between RC-4 and RC-5 may be required after aquifer testing is completed.

A.3 SOIL VAPOR EXTRACTION WELL CONSTRUCTION DETAILS

Seven extraction wells (VE-1, -2, -3, -7, -9, -10, and MW-14S) are required for the soil vapor extraction system. Soil vapor extraction wells VE-1, -2, -3, -7, -9, and -10 were constructed to a depth of 20 feet below the ground surface. These wells were constructed of 15 feet of 0.010 inch slotted PVC screen and 6 feet of PVC riser pipe. Each well contains about 16 feet of Morie #00 sand, a 1-foot bentonite seal, and is completed with a cement/bentonite mixture to the ground surface. The other well to be used in the soil vapor extraction system, MW-14S, was installed oroginally as a monitoring well during Phase I field activities. The construction criteria for this well are presented in the RCRA Facility Investigation Interim Report (November 20, 1991).

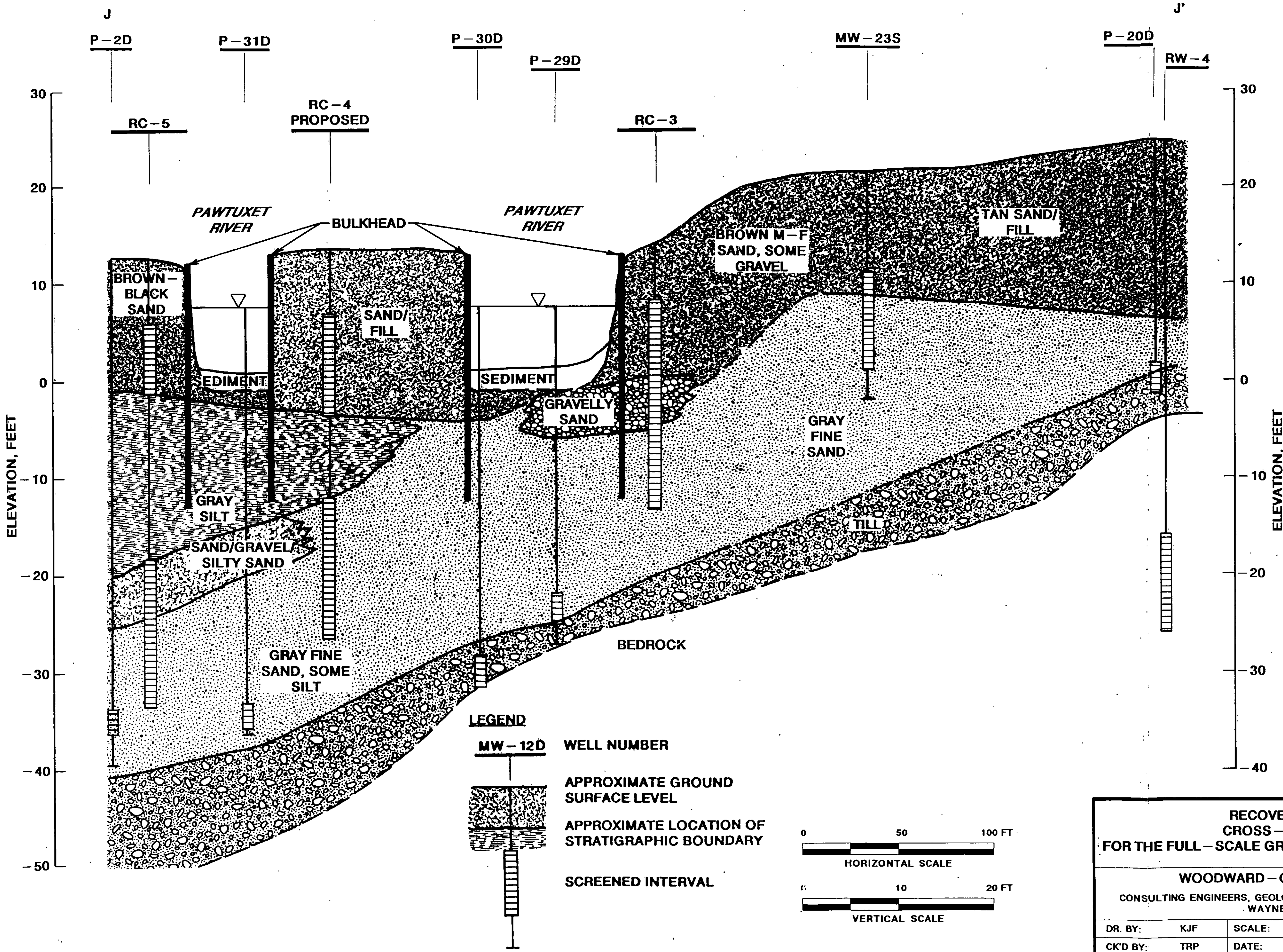
The soil vapor extraction wells are constructed with the screened interval at least 2 feet above the water table to maximize vapor recovery. Well screens generally extend through the entire saturated portion of the Fill unit. All wells (except VE-7, -9, and -10) are designed to extract both soil vapor and groundwater. VE-7, -9, and -10 are designed to extract groundwater only. Other details on the vapor recovery system are provided on the design drawings.



PROPOSED RECOVERY WELL LOCATIONS FOR THE FULL-SCALE GROUNDWATER CAPTURE SYSTEM

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR.BY	MVB	SCALE	1:720	PROJ.	87X4660
CK'D.BY	KAK	DATE	OCTOBER 27, 1993	FIG.NO.	A-1



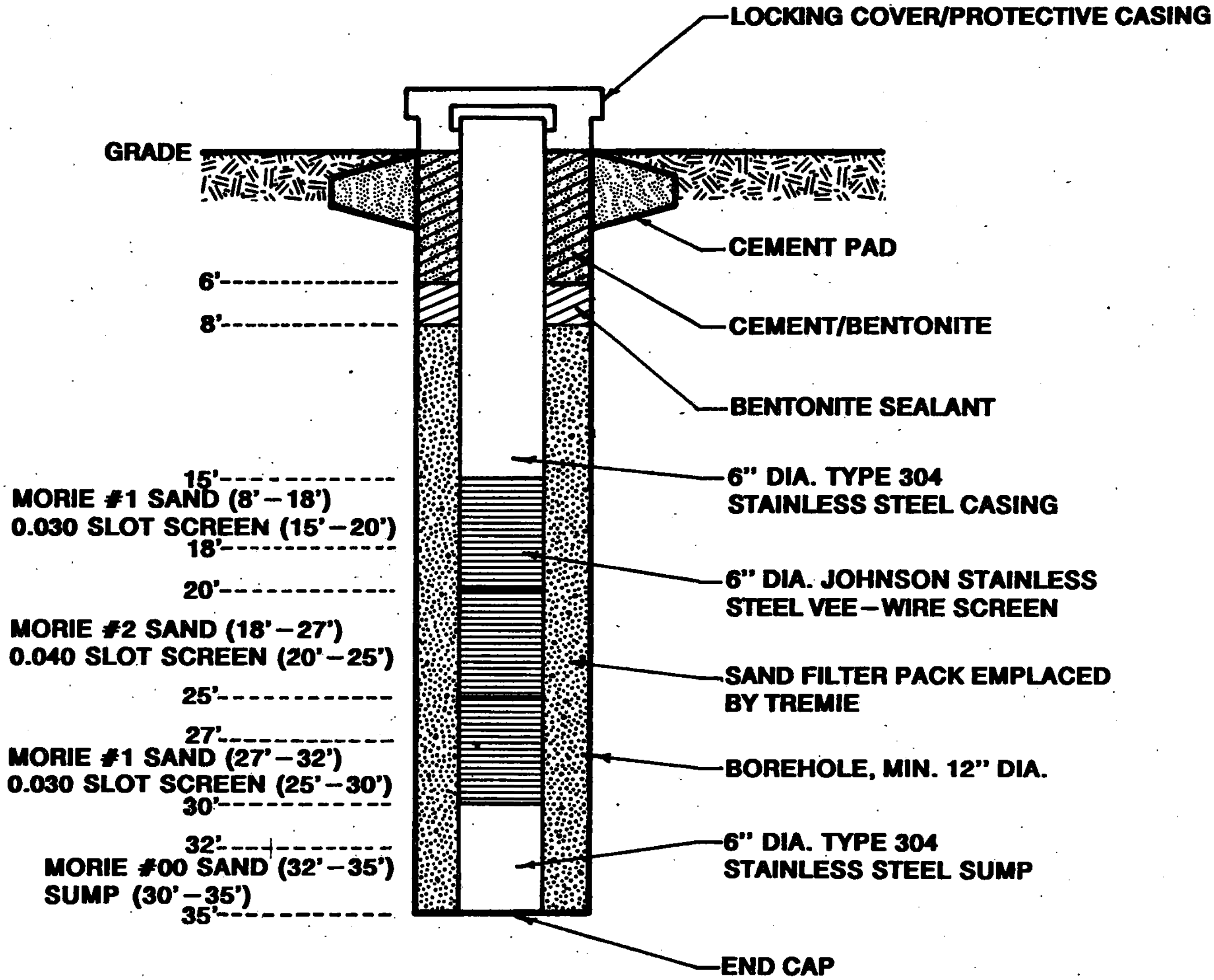
RECOVERY WELLS ON
CROSS – SECTION J – J'
FOR THE FULL – SCALE GROUNDWATER CAPTURE SYSTEM

WOODWARD – CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
WAYNE, NEW JERSEY

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	87X4660
CK'D BY:	TRP	DATE:	MAR. 8, 1993	FIG. NO.:	A-2

WELL CONSTRUCTION DETAILS (AS BUILT)
RC-3

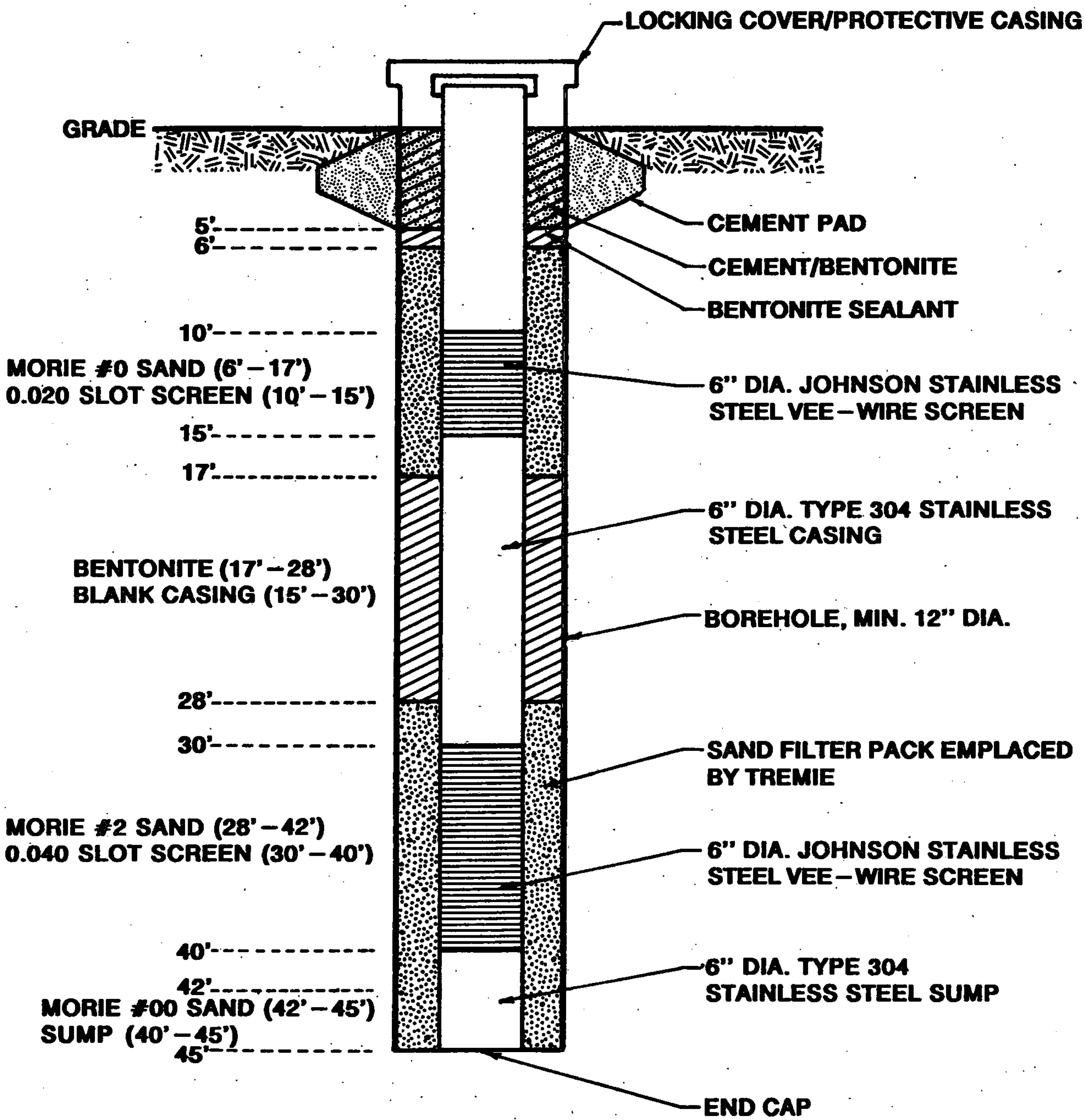


VERTICAL SCALE

HORIZONTAL NOT TO SCALE

WELL CONSTRUCTION DETAILS RC-3					
WOODWARD-CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS WAYNE, NEW JERSEY					
DR. BY:	KJFH	SCALE:	AS SHOWN	PROJ. NO.:	87X4660
CK'D BY:	TRP	DATE:	OCT. 25, 1993	FIG. NO.:	A-3

WELL CONSTRUCTION DETAILS (AS BUILT)
RC–5



0 8 16 FT

VERTICAL SCALE

HORIZONTAL NOT TO SCALE

WELL CONSTRUCTION DETAILS RC–5

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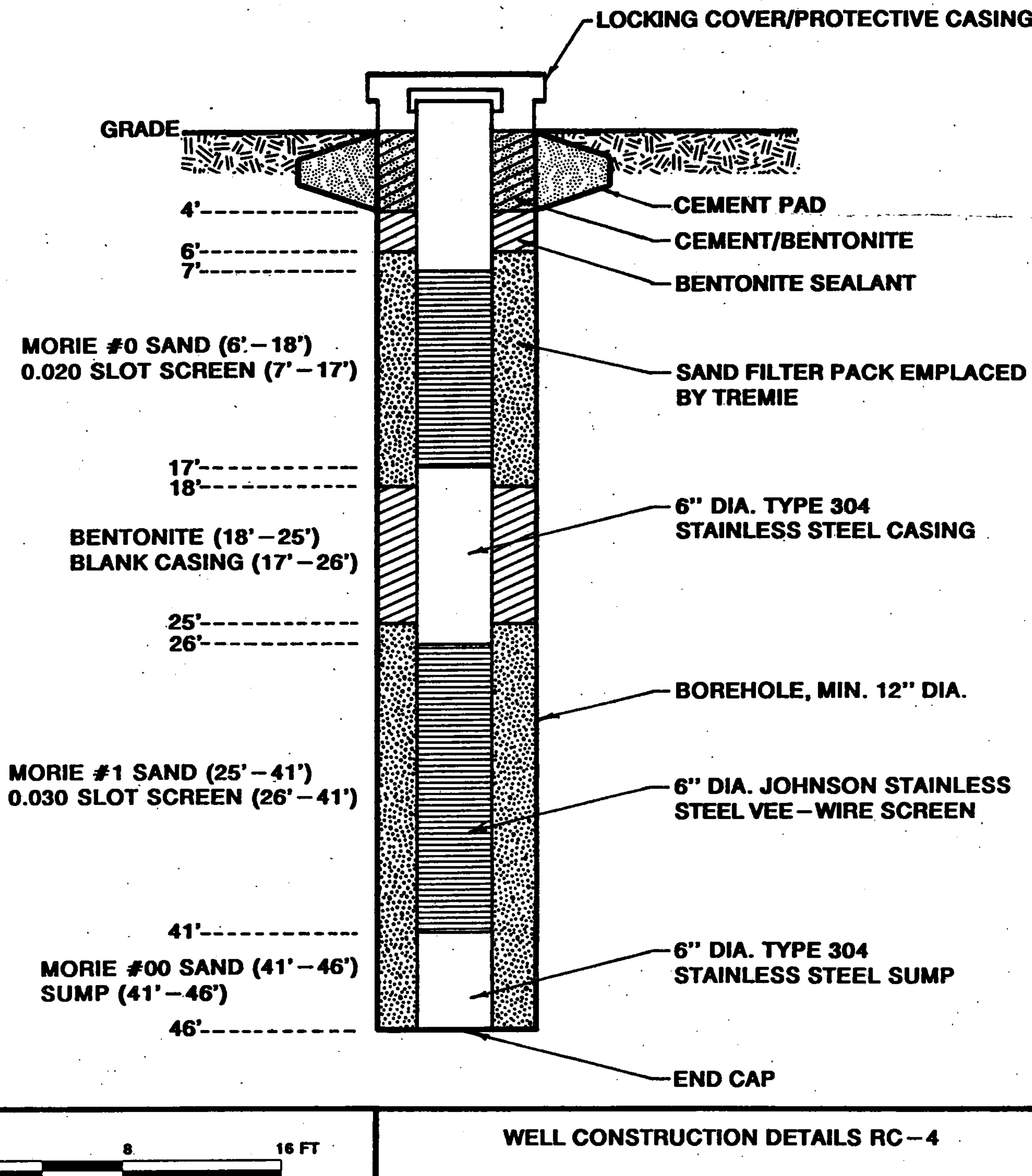
WAYNE, NEW JERSEY

DR. BY:	KJFH	SCALE:	AS SHOWN	PROJ. NO.:	87X4660
CK'D BY:	TRP	DATE:	OCT. 25, 1993	FIG. NO.:	A–4

WELL CONSTRUCTION DETAILS (PROPOSED)
RC-4



VERTICAL SCALE

HORIZONTAL NOT TO SCALE

WELL CONSTRUCTION DETAILS RC-4

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WAYNE, NEW JERSEY

DR. BY:	KJFH	SCALE:	AS SHOWN	PROJ. NO.:	87X4660
CK'D BY:	TRP	DATE:	OCT. 25, 1993	FIG. NO.:	A-5

ATTACHMENT 1
RECOVERY WELL BORING LOGS

WOODWARD–CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

LOG OF BORING RC-3 SHEET 1 OF 2

PROJECT AND LOCATION: Ciba-Geigy Cranston, Rhode Island		ELEVATION AND DATUM:	PROJECT NO.:
DRILLING AGENCY: Burlington Environmental	FOREMAN: ?	DATE STARTED: 7/8/93	DATE FINISHED: 7/8/93
DRILLING EQUIPMENT: CME-75		COMPLETION DEPTH: 42'	ROCK DEPTH: NA
SIZE AND TYPE OF BIT: 4 1/4" I.D. HSA	SIZE AND TYPE CORE BARREL: NA	NO. SAMPLES: DIST. 21	UNDIST. NA / CORE NA
CASING: NA		WATER LEVEL: FIRST ~7'	COMPL. / 24 HR.
CASING HAMMER	WEIGHT: NA / DROP: NA	BORING ANGLE AND DIRECTION: vertical	
SAMPLER: 2" split spoon		INSPECTOR: J. M. Richart	
SAMPLER HAMMER	WEIGHT: 140 lb. / DROP: 30"		

DESCRIPTION	PIEZOMETER	DEPTH, FT	SAMPLES: TYPE NO. LOC	RECOV, FT	PENETR. RESIST BL/6IN.	TIME	HNU/PID READINGS (PPM): SAMPLE	AMBIENT AIR	TIME	REMARKS
FILL; broken concrete and brown SILT & f. GRAVEL		0–2	SS-1	1.33	8 15 44 R	10:05	0.9	0.8	10:08	Hit obstruction at 1.5 ft; could not advance spoon any further
SP; loose brown f-m SAND & GRAVEL, some silt, moist, wood & broken concrete in spoon tip		2–4	SS-2	1	7 7 8 11	10:13	0.9	0.9	10:18	
SM; loose dk gray f-m SAND, some gravel, moist		4–6	SS-3	1.17	8 4 4 2	10:15	0.8	0.8	10:27	
SM (first 6"); loose brown silty f-m SAND & GRAVEL, with wood SP (rest of spoon); loose dk gray m SAND & GRAVEL, with wood		6–8	SS-4	1.33	3 5 7 6	10:26	1.0	0.8		
SP; loose dk gray m SAND & GRAVEL, with wood		8–10	SS-5	0.33	1 W 1 0		0.9	0.9	10:45	
SAA (first 10") ML (next 6"); [illegible] lt. gray SILT with occasional sandy seams GP (rest of spoon); loose dk gray f. GRAVEL & SAND		10–12	SS-6	1.67	3 3 9 11		1.0	0.9	10:48	10:43 0.? ppm borehole 0.8 ppm breathing zone
SW; very loose dk gray m SAND, with trace f. gravel		12–14	SS-7	1.5	2 3 3 4		0.8	0.6	11:00	
SW; loose dk gray c. SAND, trace gravel		14–16	SS-8	1.25	4 3 3 4	10:5?	0.9	0.9	11:09	
SW (first 12"); loose dk gray c. SAND SW (rest of spoon); loose lt. gray m-f SAND		16–18	SS-9	1.75	5 [illegible] 5 4	11:02	0.9	0.9	11:16	
SAA with frequent dk gray silt laminae		18–20	SS-10	1.25	5 7 7 7	11:38	0.8	0.8	11:41	

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LOG OF BORING: RC-3 | SHEET 2 OF 2

DESCRIPTION	PIEZOMETER	DEPTH, FT	SAMPLES: TYPE NO. LOC	SAMPLES: RECOV, FT	SAMPLES: PENETR RESIST BL/6IN.	SAMPLES: TIME	HNU READINGS (PPM): SAMPLE	HNU READINGS (PPM): AMBIENT AIR	HNU READINGS (PPM): TIME	REMARKS
SW; loose lt. gray m-f SAND		21 22	SS-11	1.5	2 2 4 4	11:44	1.0 to 1.2	0.8	11:50	11:56 0.9 ppm borehole 0.8 ppm breathing zone
SAA		23 24	SS-12	2	4 5 6 7	11:52	0.9 to 1.0	0.8	11:58	
SAA (first 10") SM (rest of spoon); loose lt. gray silty f. SAND		25 26	SS-13	1.42	1 2 5 7	12:04	1.1	1.0	12:08	
SM; loose lt. gray silty f. SAND		27 28	SS-14	1.25	1 3 4 5	13:36	0.8	0.7	13:40	
SM (first 8"); very loose lt. gray silty c. SAND SM (rest of spoon), very loose lt. gray silty m-f SAND		29 30	SS-15	1.58	W 1 2 2	13:42	1.5	1.4	13:48	
SM; very loose lt. gray silty m-f SAND		31 32	SS-16	2	1 1 2 3	13:49	1.5	1.3	13:57	
SAA (first 16") ML (rest of spoon); soft lt. gray SILT, trace f. sand		33 34	SS-17	2	W 3 4 3	14:00	1.3	1.1	14:04	14:02 1.3 ppm borehole 1.2 ppm breathing zone
SW (first 14"); very loose lt. gray m. SAND, with frequent orangish-brown m. sandy seams SP (rest of spoon); very loose lt. gray silty f. SAND		35 36	SS-18	2	1 1 3 5	14:08	1.2	1.1	14:13	
SP (first 15"); very loose lt. gray silty f. SAND SW (rest of spoon); very loose lt. gray m. SAND, with frequent orangish-brown m. sandy seams		37 38	SS-19	2	2 1 3 3	11:54	1.0	0.7	14:59	
SP (first 15"); loose lt. gray silty f. SAND ML (next 5"); med. stiff dk. gray SILT stiff TILL (rest of spoon)		39 40	SS-20	1.67	4 5 11 18	15:03	0.9	0.5	15:05	Drilled to 40'; spooned to 42'
stiff TILL		41 42	[illegible]	2	9 21 11 15	15:18	0.9	0.8	15:21	16:03 0.7 ppm borehole 0.5 ppm breathing zone
		43 44								

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LOG OF BORING RC-5 SHEET 1 OF 3

PROJECT AND LOCATION: Ciba-Geigy Cranston, Rhode Island		ELEVATION AND DATUM:	PROJECT NO.: 87X4F60
DRILLING AGENCY: Burlington Environmental	FOREMAN:	DATE STARTED: 7/7/93	DATE FINISHED: 7/7/93
DRILLING EQUIPMENT: CME-75		COMPLETION DEPTH: 50'	ROCK DEPTH: NA
SIZE AND TYPE OF BIT: 4 1/4" I.D. HSA	SIZE AND TYPE CORE BARREL: NA	NO. SAMPLES: DIST 26	UNDIST NA / CORE NA
CASING: NA		WATER LEVEL: FIRST ~5'	COMPL. / 24 HR
CASING HAMMER: NA	WEIGHT: NA / DROP: NA	BORING ANGLE AND DIRECTION: Vertical	
SAMPLER: 2" split spoon		INSPECTOR: J. M Rickert	
SAMPLER HAMMER	WEIGHT: 140 lb / DROP: 30"		

DESCRIPTION	PIEZOMETER	DEPTH, FT	SAMPLES TYPE NO. LOC	RECOV, FT	PENETR. RESIST BL/6IN.	TIME	HNU/PID READINGS (PPM) SAMPLE	AMBIENT AIR	TIME	REMARKS
FILL; broken concrete and bricks; large stones in spoon tip		1	SS-1	1.0	10 20 31 7	08:53	1.2	1.4	[illegible]	Drill refusal after 2 ft; relocated
SM; loose brown silt, SAND, some gravel, moist, [illegible] stained soil in spoon tip		3	SS-2	[illegible]	8 7 [illegible] [illegible]	09:07	1.8	1.4	09:12	09:07 1.4 ppm [illegible] 1.4 ppm breathing zone
GM; [illegible] dk gray silty GRAVEL, [illegible] sand, wet		5	SS-3	1	1 1 0 0	09:09	1.6	1.4	[illegible]	
SAA ML (last 3"); very soft dk gray SILT		7	SS-4	1	W W	09:22	1.4 to [illegible]	1.2	[illegible]	
GM (top 5"); [illegible] loose dk gray silty GRAVEL; some sand ML (rest of sp.) soft brown SILT with [illegible] fragments		9	SS-5	N	W W	09:27	1.4	1.2	[illegible]	09:31 4-[illegible] ppm [illegible] hole 1.4 ppm breathing zone
SAA (top [illegible]) ML (rest of sp.); soft brown SILT with frequent sandy seams		11	SS-6	N	[illegible]		1.5 to [illegible]	0.7	[illegible]	
ML; soft brown SILT with frequent sandy seams		13	SS-7	0.67	W 1 0 0	09:47	3.8	0.7	10:07	09:59 4-18 ppm in hole 1.2 ppm breathing zone
SAA (top 6") GM (next 6"); loose dk gray SAND & GRAVEL [illegible] silt CL (rest of sp.); soft dk gray silty CLAY		15	[illegible]	1.67	[illegible]		2.4	0.0	[illegible]	
CL; soft dk gray silty CLAY		17	SS-9	N	[illegible]	10:[illegible]	1.1	0.7	10:37	
SAA		19	SS-10	1.5	11 [illegible]	10:33	0.7	0.7	10:43	

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LOG OF BORING RC-5

DESCRIPTION	PIEZOMETER	DEPTH, FT	SAMPLES: TYPE NO. LOC	SAMPLES: RECOV., FT	SAMPLES: PENETR. RESIST. BL/6IN.	SAMPLES: TIME	HNU READINGS (PPM): SAMPLE	HNU READINGS (PPM): AMBIENT AIR	HNU READINGS (PPM): TIME	REMARKS
CL (top 7"); soft lt. gray silty CLAY, some gravel CL (rest of sp.); med. stiff lt. gray silty CLAY		21	SS-11	1.58	1 1 4 6	10:39	0.9	0.9	10:50	
CL; med. stiff lt. gray silty CLAY		22–23	SS-12	0.92	4 3 4 5	10:49	0.8	0.8	10:59	
SC; loose lt. gray silty f SAND		24–25	SS-13	2	8 4 3 4	10:58	1.0	0.8	11:07	11:06 4.8 to 9.4 ppm borehole 0.8 ppm breathing zone
SAA (top 10") CL (rest of sp.); med stiff lt. gray silty CLAY		26–27	SS-14	1.75	3 4 5 5	11:34	1.2	1.0		11:29 0.4 - 1.4 ppm borehole 0.8 ppm breathing zone
ML; stiff lt. gray clayey SILT		28–29	SS-15	1.42	8 8 5 6	11:42	0.9	0.4	11:48	
SC; loose lt. gray silty m-f SAND		30–31	SS-16	1.33	5 3 3 4	11:46	0.9	0.4	11:54	
SP; very loose lt. gray c-m SAND; trace gravel		32–33	SS-17	0.75	1 2 5 8	11:55	1.0	1.0	12:01	
SAA (first [illegible]) GP (rest of sp.); loose lt. gray c. GRAVEL, some c-m sand		34–35	SS-18	1.42	13 10 11 18	12:02	0.7	0.6	12:10	
SP; med. dense lt. gray c-m SAND; minor gravel		36–37	SS-19	0.42	20 25 4 17	16:[illegible]	1.3	1.2	16:17	
SP (top 7"); loose lt. gray SAND & GRAVEL SW (rest of sp.); loose lt. gray m. SAND		38–39	SS-20	1.25	[illegible]	[illegible]	0.9	0.6	16:26	
SW (first 12"); loose lt. gray m. SAND SW (rest of sp.); very loose lt. gray f. SAND		40–41	SS-21	2	1 2 2 3	16:30	0.8	0.7		16:41 1.0 ppm borehole 0.7 ppm breathing zone
SW (first 12"); very loose lt. gray f. SAND ML (rest of sp.); very soft lt. gray SILT; trace f. SAND		42–43	SS-22	1.67	W 1 W 1	16:38	0.6	0.6	16:[illegible]	
		44								

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CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

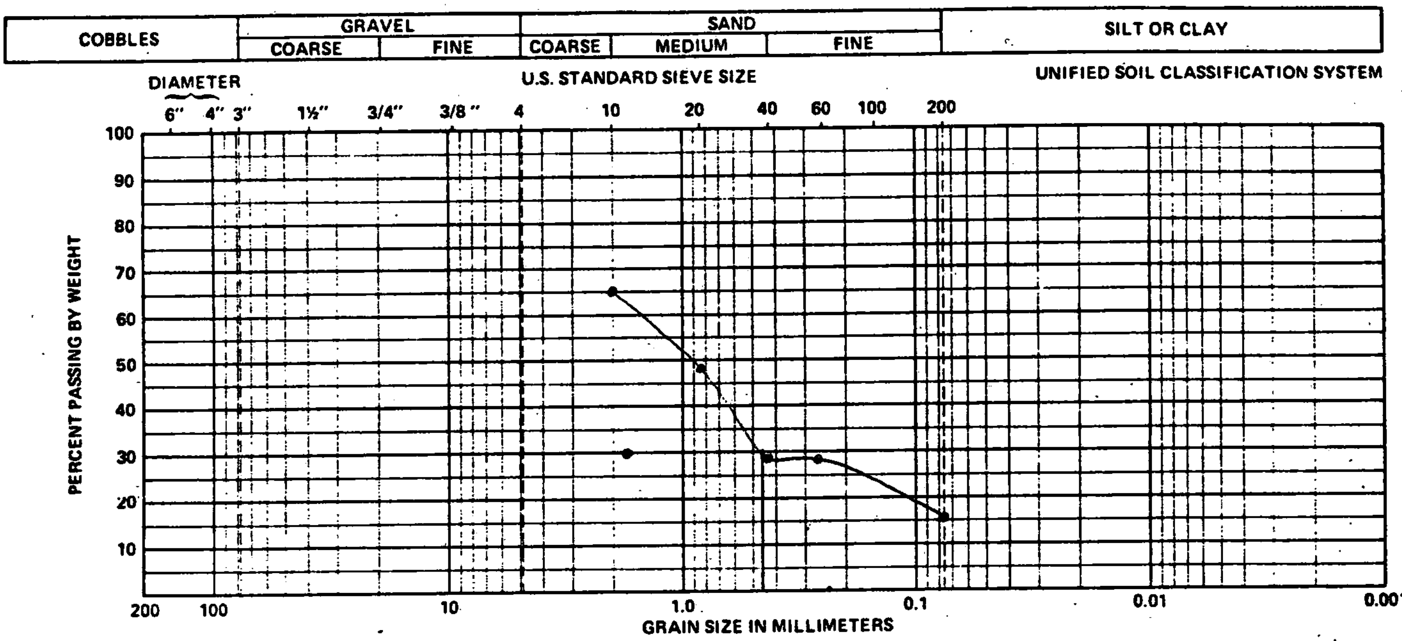
LOG OF BORING RC-5 SHEET 3 OF 3

DESCRIPTION	PIEZOMETER	DEPTH, FT	SAMPLES TYPE NO. LOC	SAMPLES RECOV, FT	SAMPLES PENETR RESIST BL/6IN.	SAMPLES TIME	HNU READINGS (PPM) SAMPLE	HNU READINGS (PPM) AMBIENT AIR	HNU READINGS (PPM) TIME	REMARKS
SAA		46	SS-23	N	W 4	16:50	1.0	0.5	17:04	
ML (first 14"); soft dk. gray SILT CL (rest of sp.); soft lt. gray silty CLAY		47, 48	SS-24	N	W W 2 2	16:59	0.8	0.7	17:13	
CL (first 12"); soft lt. gray silty CLAY ML (next 7"); med. stiff dk. gray SILT; trace f. gravel Hard TILL (rest of sp.)		49, 50	SS-25	N	W 3 10 50	17:08	0.9	0.4	17:24	Drilled to 50'; spooned to 51' 3"
Hard TILL		51, 52	SS-26	1.25	10 40 50/3"	17:34	1.0	0.5	17:42	17:48 2.0 ppm borehole 0.8 ppm breathing zone
		53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69								17:56 2.0 ppm borehole 1.0 ppm breathing zone

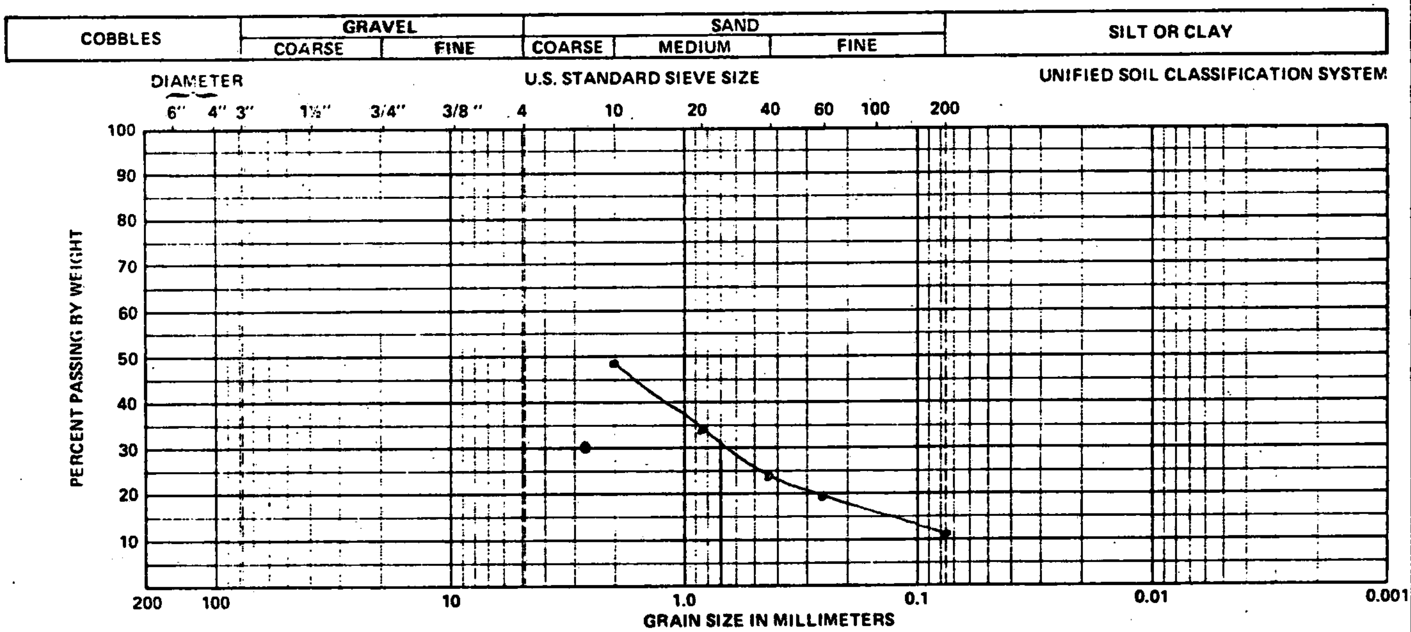
ATTACHMENT 2

RECOVERY WELL CONSTRUCTION GRAIN SIZE ANALYSES

PARTICLE-SIZE DISTRIBUTION

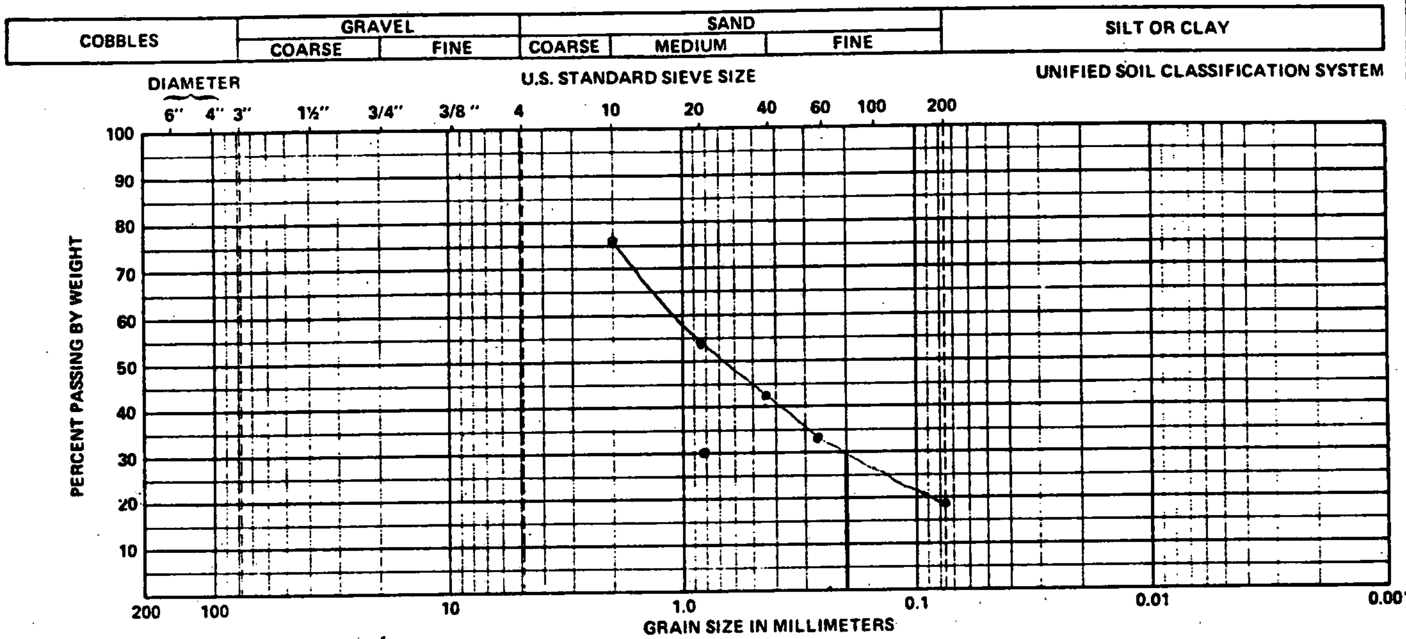


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-4A	6-8		D_{30} (sand pack) = (0.47)(4) = 1.88			
				UC = D_{60}/D_{10} =			
				Morie #2 ; 40-slot			

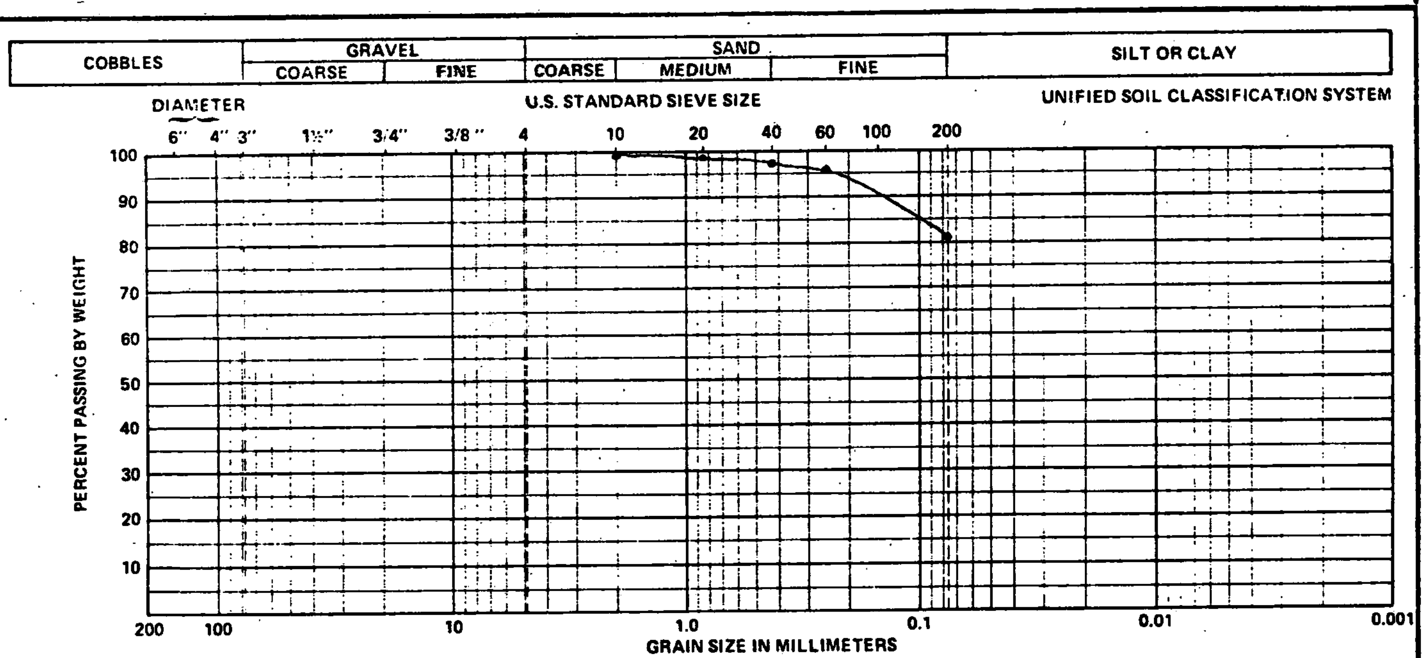


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-5	8-10		D_{30} (sand pack) = (0.7)(4) = 2.8			
				Morie #2 ; 40-slot			

PARTICLE-SIZE DISTRIBUTION

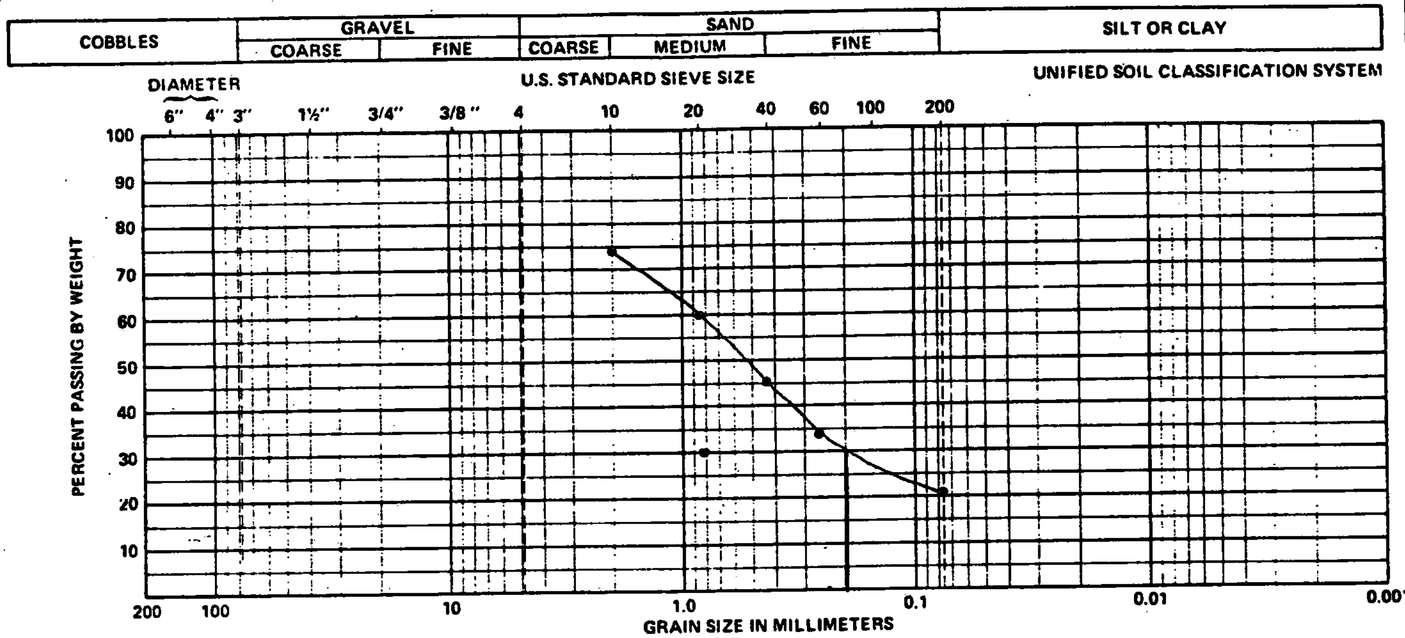


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-6A	10-12		$D_{30} = (0.2)(4) = 0.8$			
				Morie #0; 20-slot			

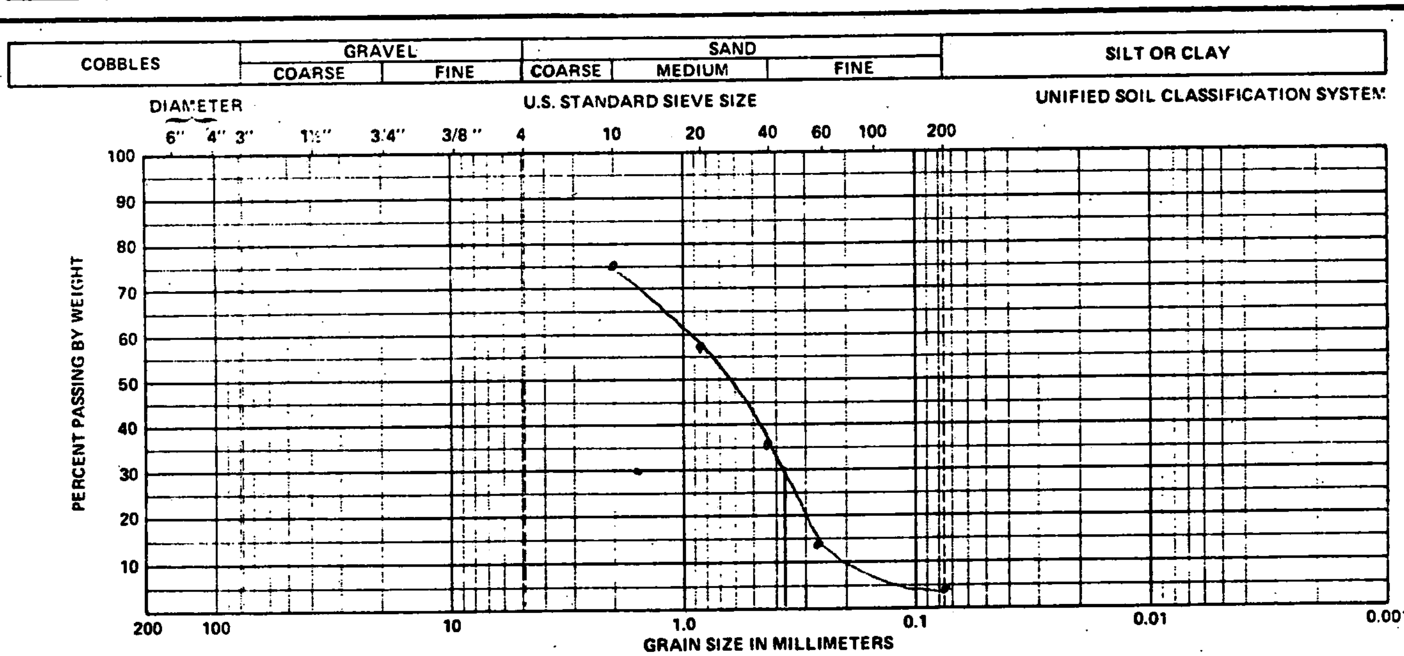


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-6B	10-12					

PARTICLE-SIZE DISTRIBUTION

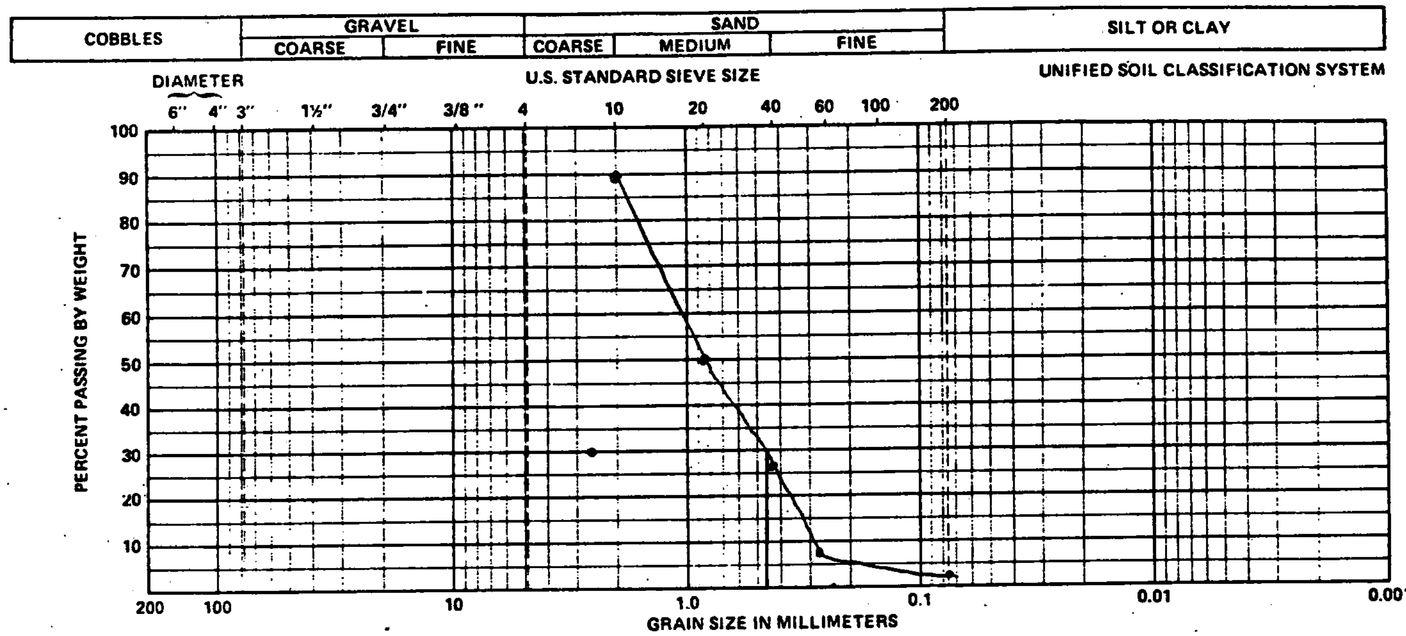


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-6C	10-12		D_{30} (sand pack) = (0.2)(4) = 0.8			
				Morie #0; 20-slot			

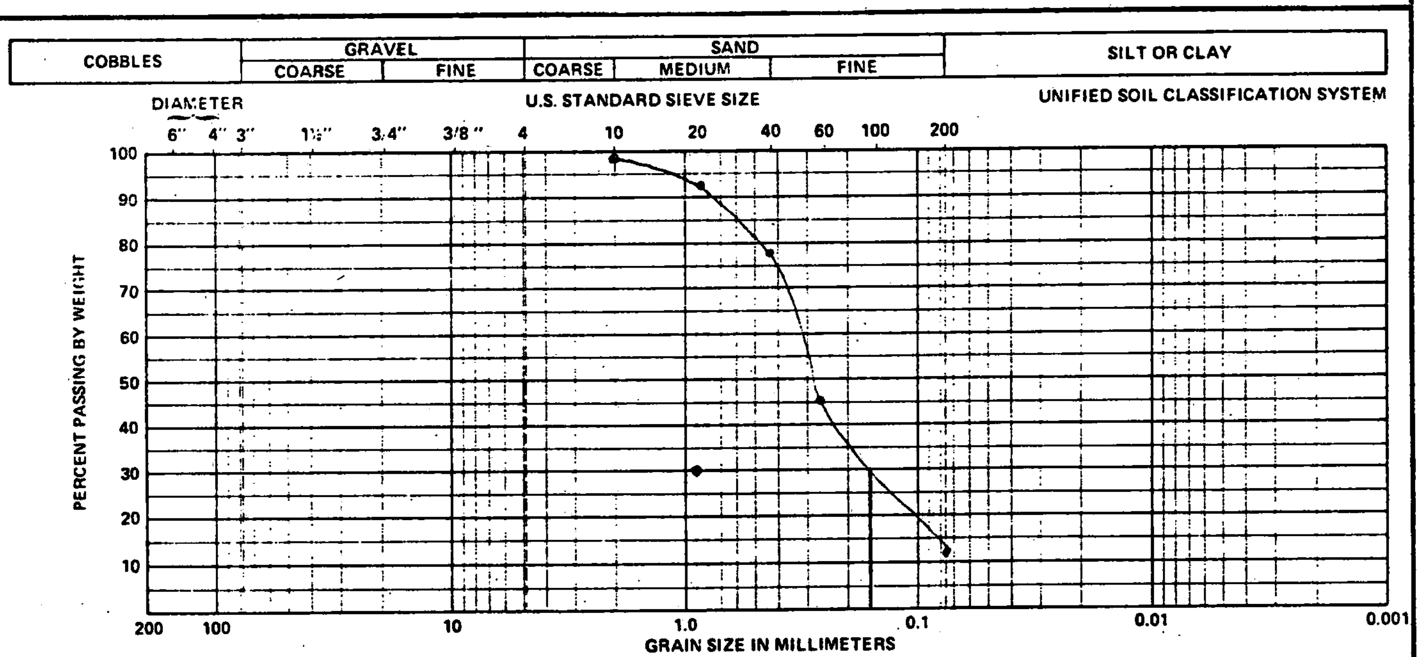


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-7	12-14		D_{30} (sand pack) = (0.37)(5) = 1.85			
				Morie #2; 40-slot			

PARTICLE-SIZE DISTRIBUTION



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-8	14-16		D_{30} (sand pack) = (0.46)(6) = 2.76			
				Morie #2 ; 40-slot			

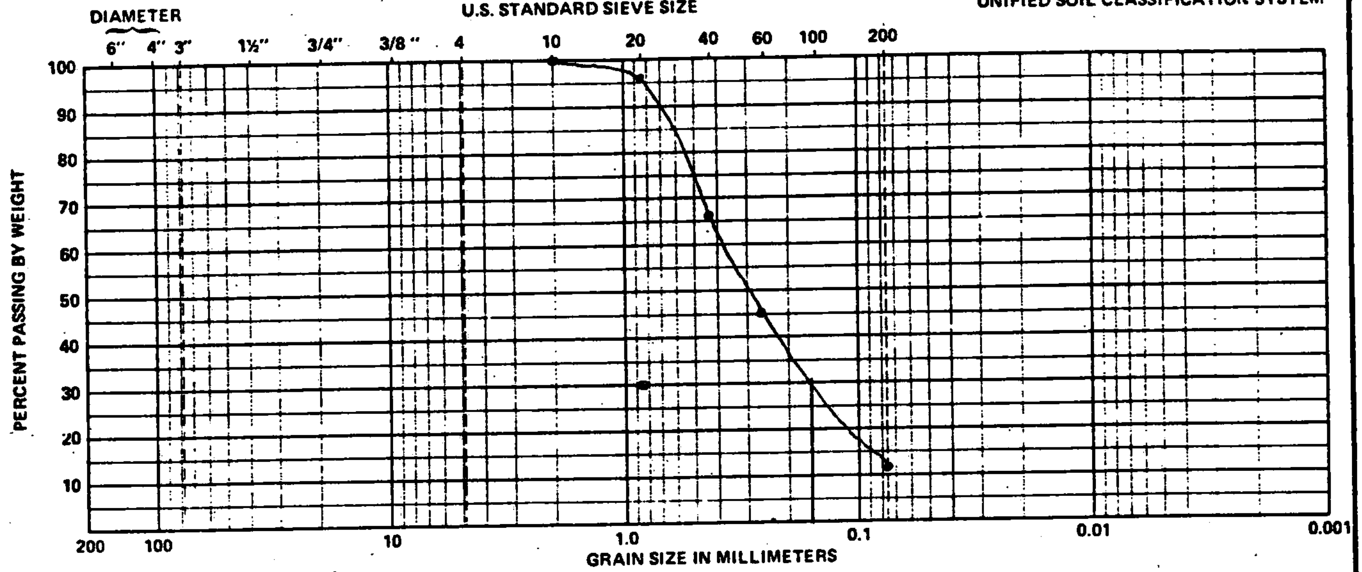


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-9A	16-18		D_{30} (sand pack) = (0.18)(5) = 0.9			
				Morie #1 ; 30-slot			

PARTICLE-SIZE DISTRIBUTION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

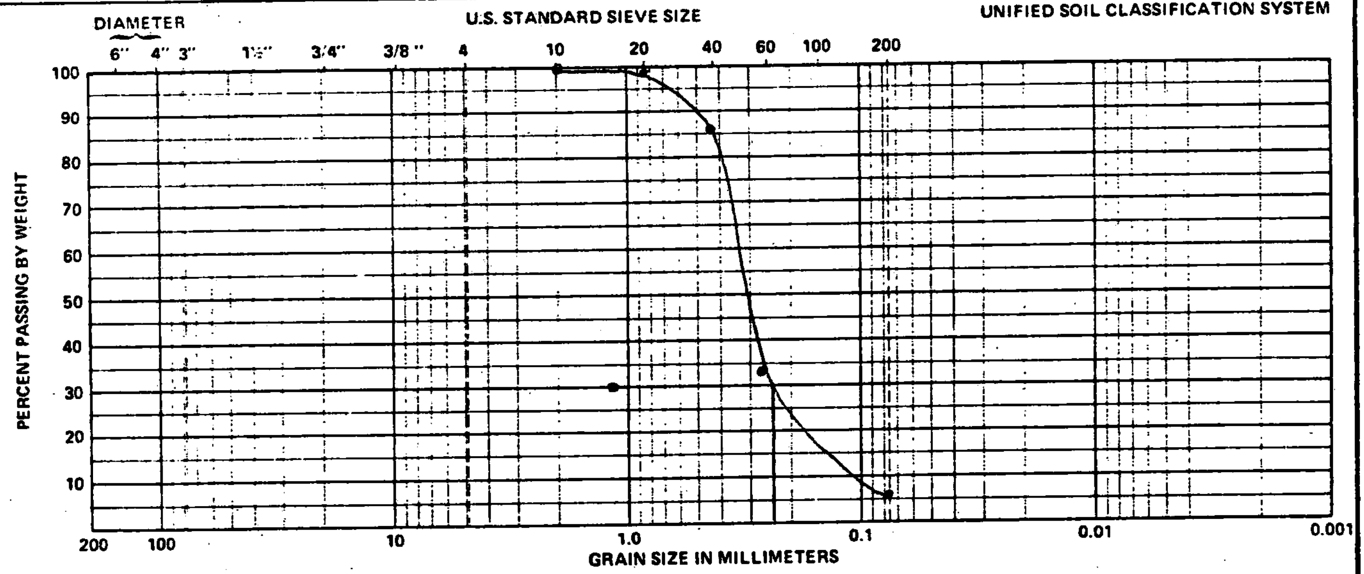
UNIFIED SOIL CLASSIFICATION SYSTEM



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-9B	16-18		D30(sand pack) = (0.17)(5) = 0.85			
				Morie #0; 20-slot			

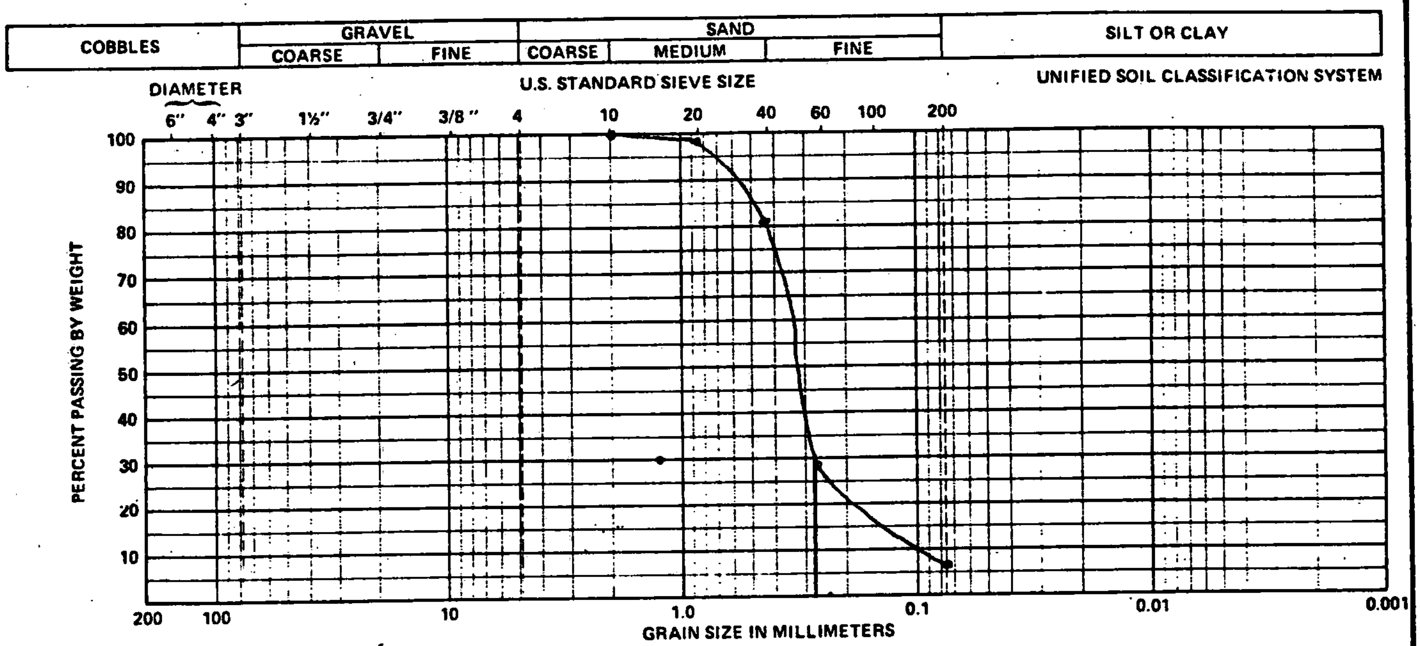
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

UNIFIED SOIL CLASSIFICATION SYSTEM

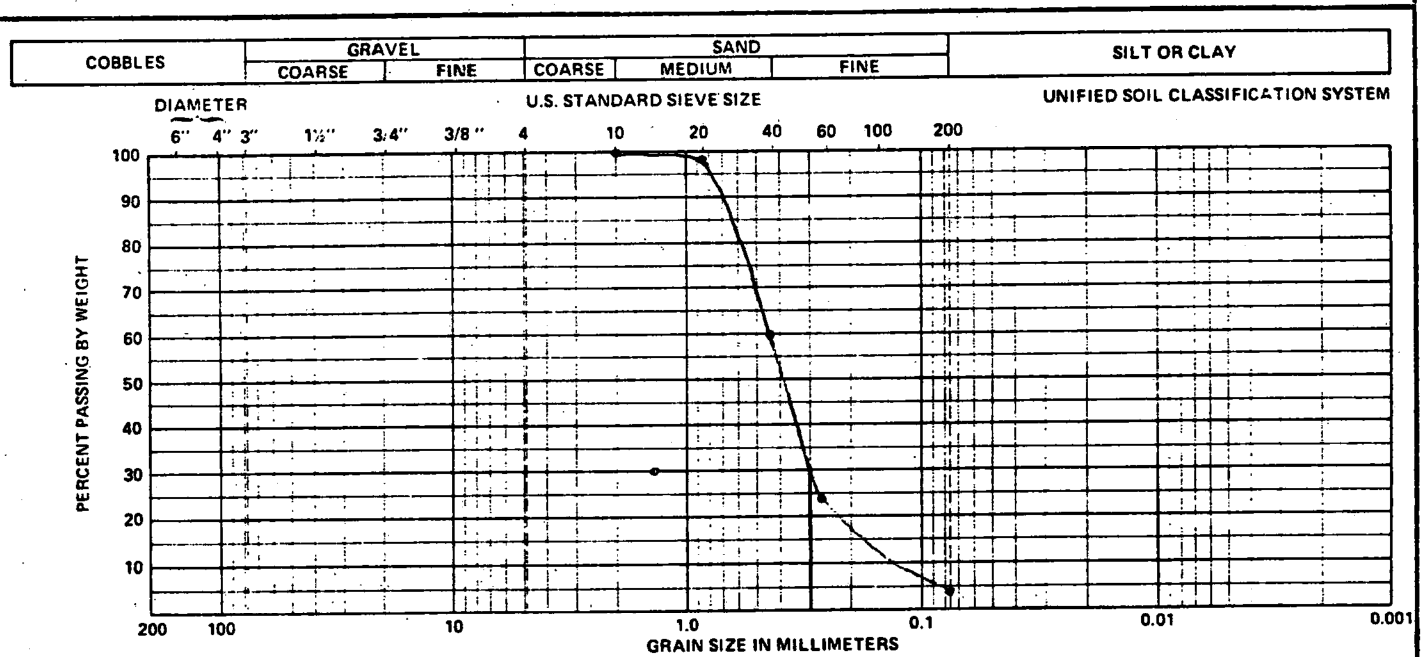


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-10	18-20		D3o(sand pack) = (0.25)(5) = 1.25			
				Morie #1; 30-slot			

PARTICLE-SIZE DISTRIBUTION

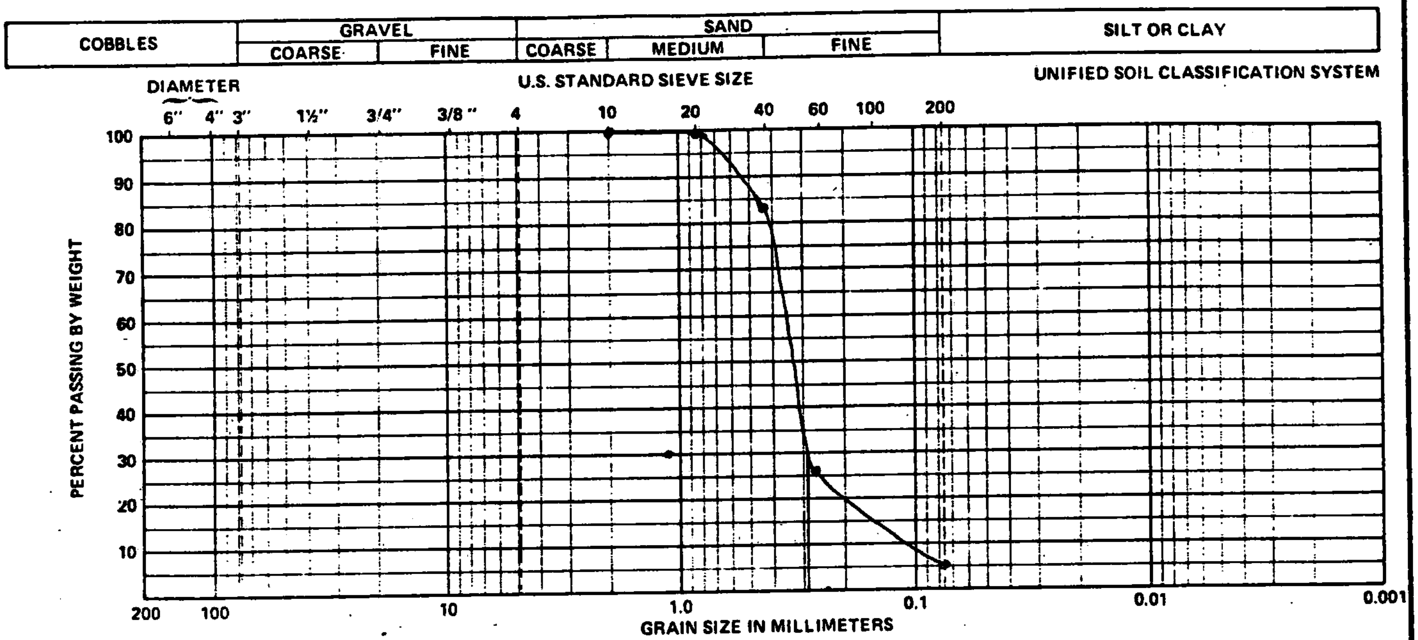


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-11	20-22		D_{30} (sand pack) = (0.28)(5) = 1.4			
				Morie #2 ; 40-slot			

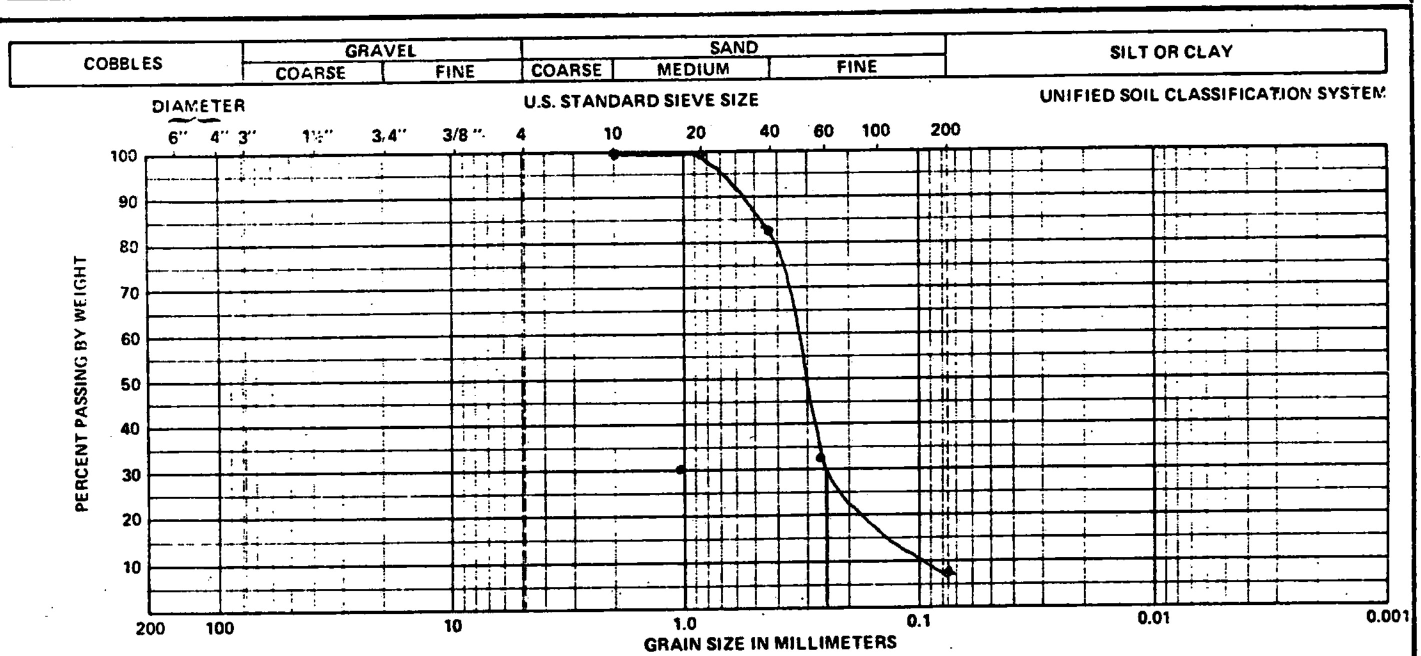


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-12	22-24		D_{30} (sand pack) = (0.3)(5) = 1.5			
				Morie #2 ; 40-slot			

PARTICLE-SIZE DISTRIBUTION

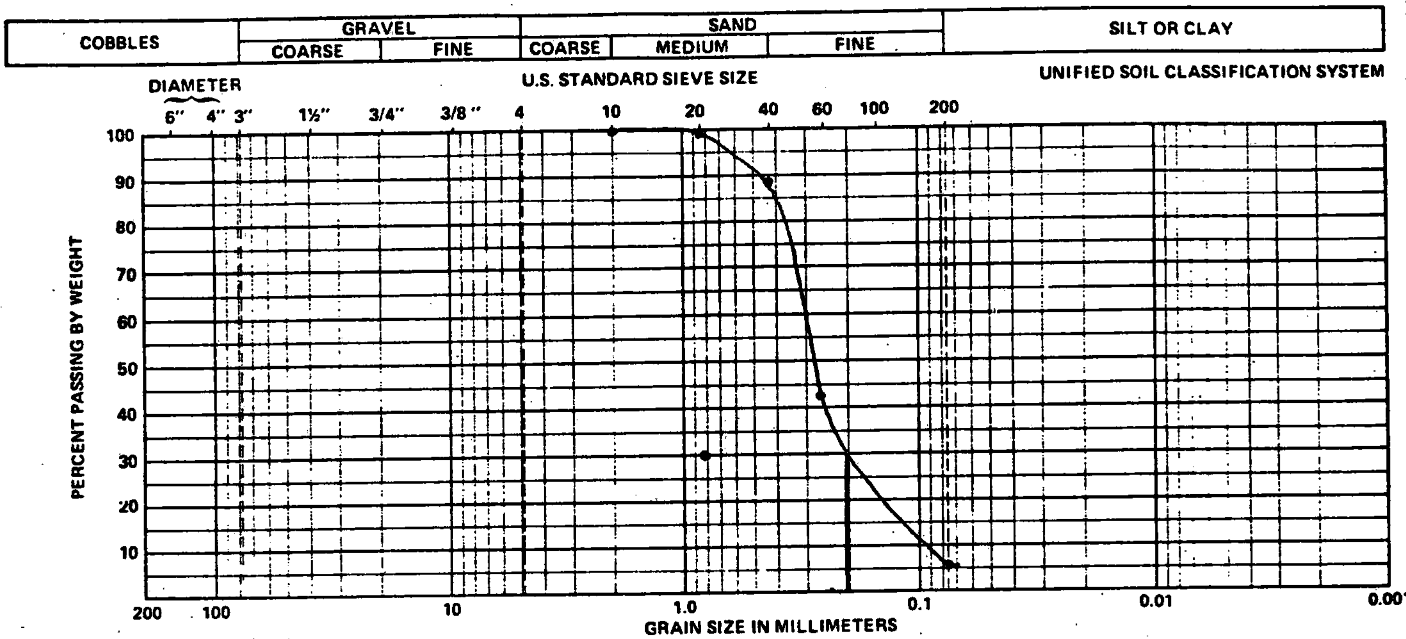


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-13A	24-26		D_{30} (sand pack) = (0.29)(4) = 1.16			
				Morie #1; 30-slot			

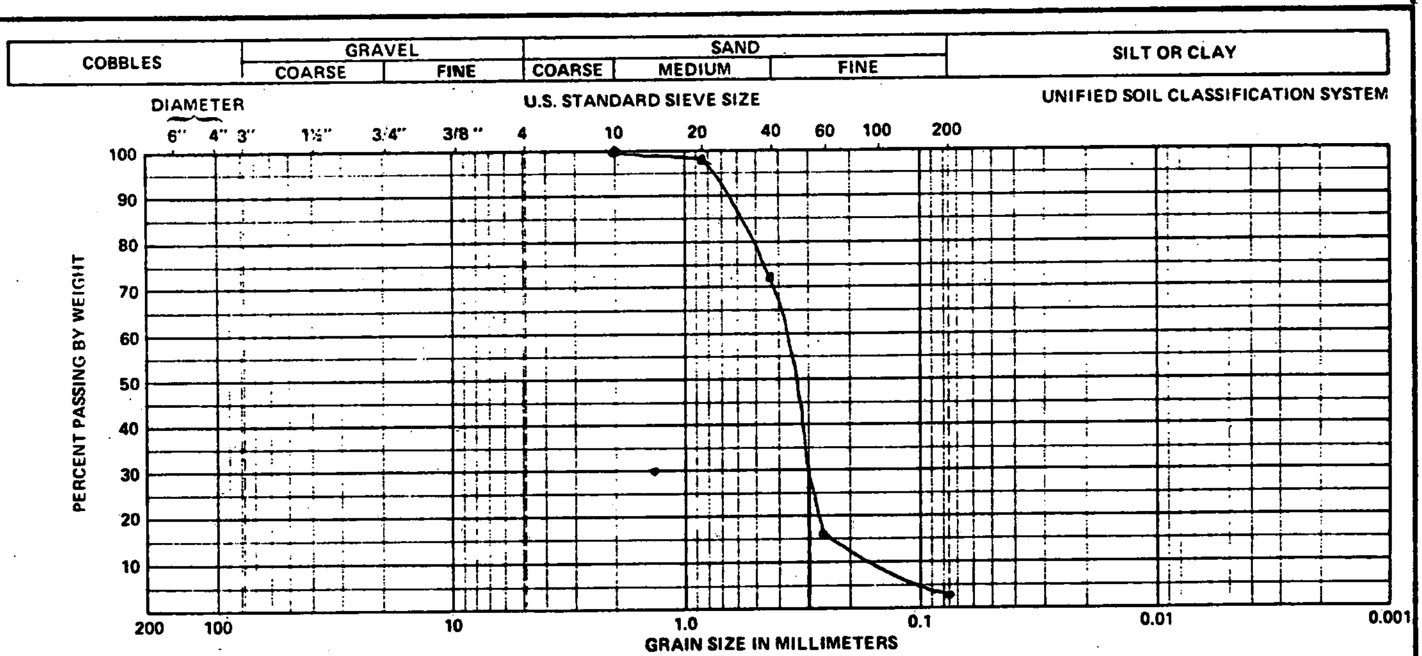


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-13B	24-26		D_{30} (sand pack) = (0.26)(4) = 1.04			
				Morie #1; 30-slot			

PARTICLE-SIZE DISTRIBUTION



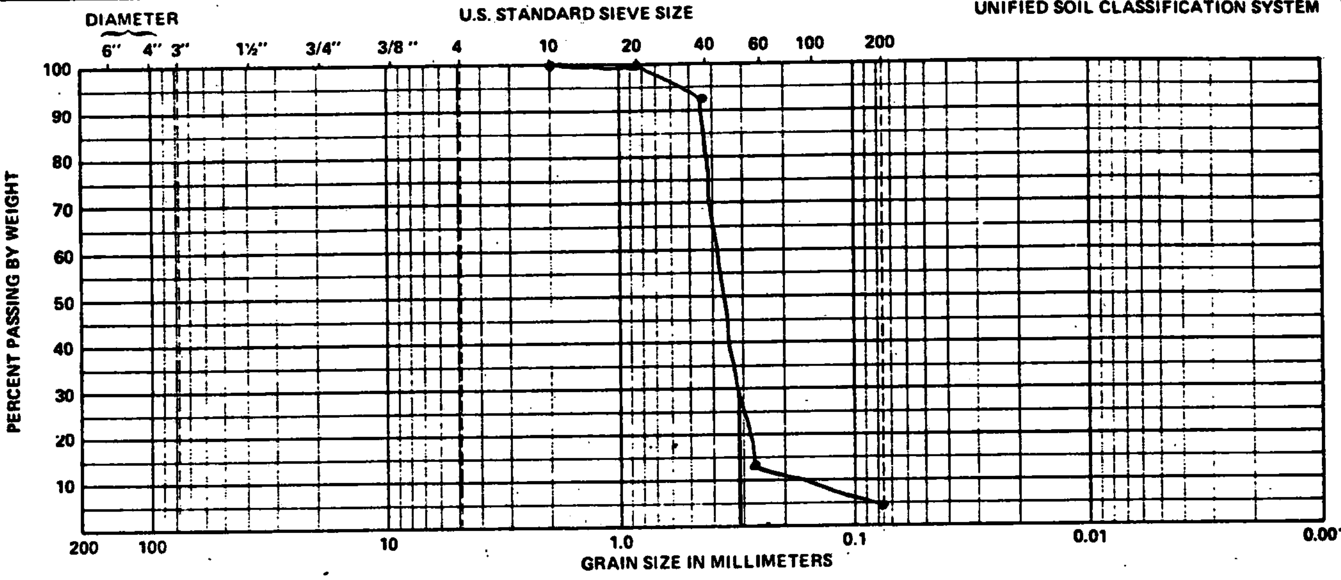
BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-14	26-28		D_{30} (sand pack) = (0.2)(4) = 0.8			
				Morie #0 ; 20-slot			



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-15A	28-30		D_{30} (sand pack) = (0.3)(5) = 1.5			
				Morie #2 ; 40-slot			

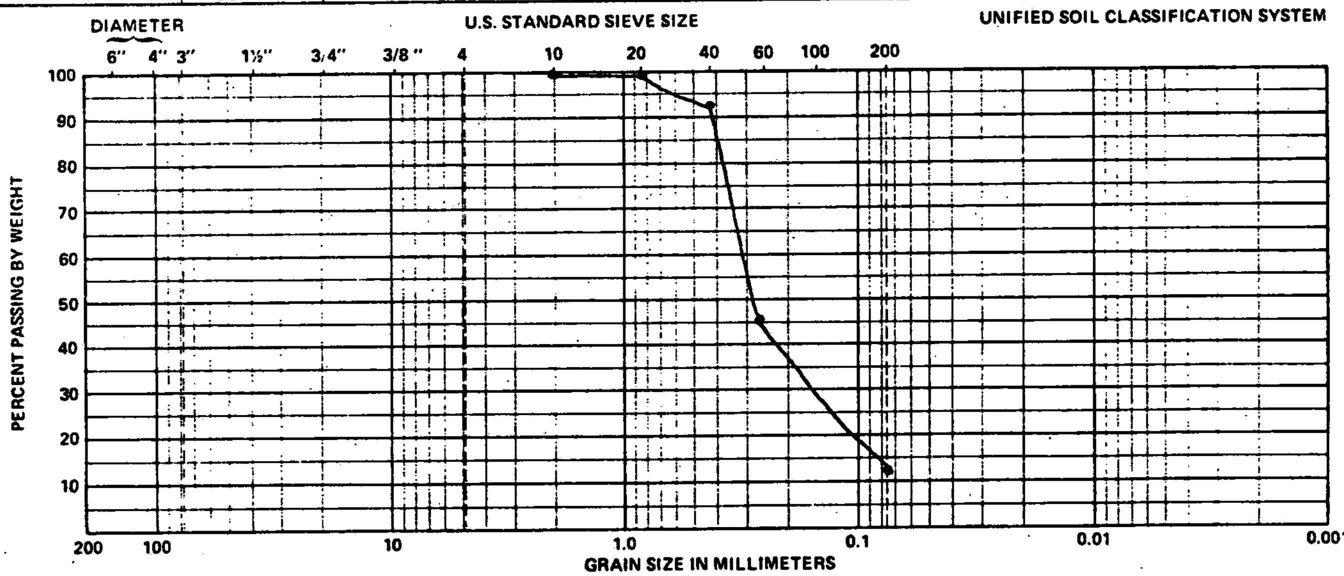
PARTICLE-SIZE DISTRIBUTION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



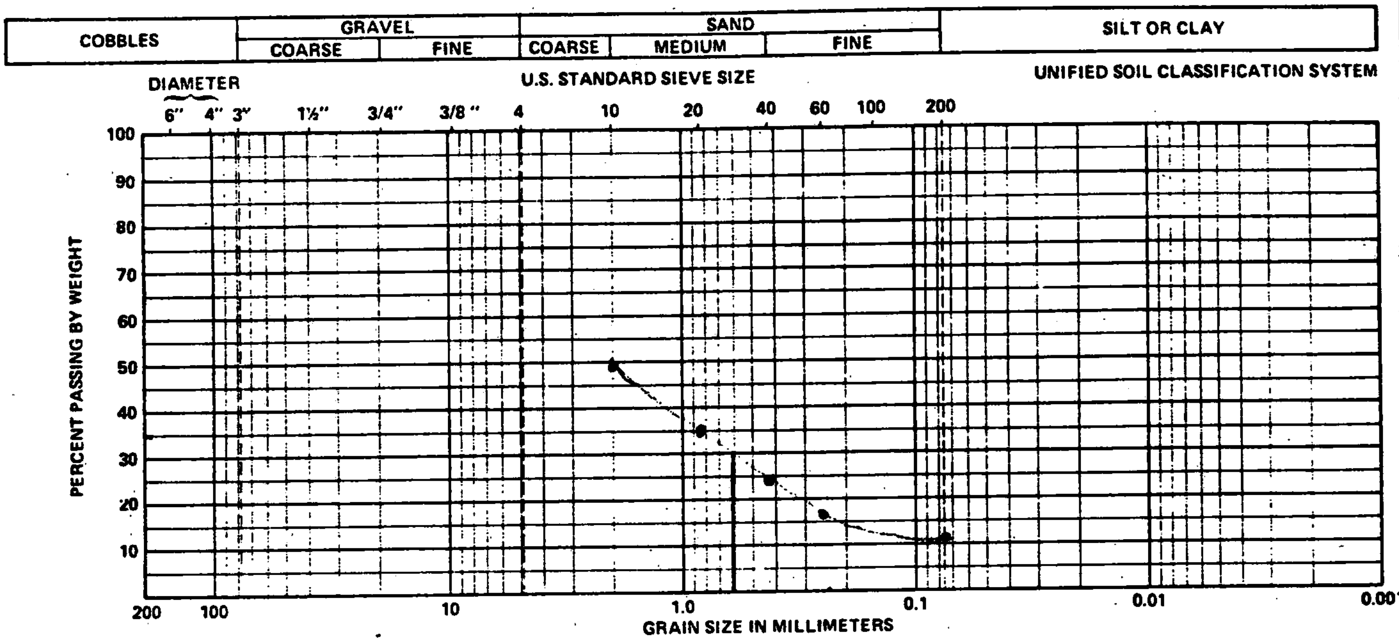
BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-15B	28-30		D_{30} (sand pack) = (0.31)(5) = 1.55			
				Morie #2 ; 40-slot			

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

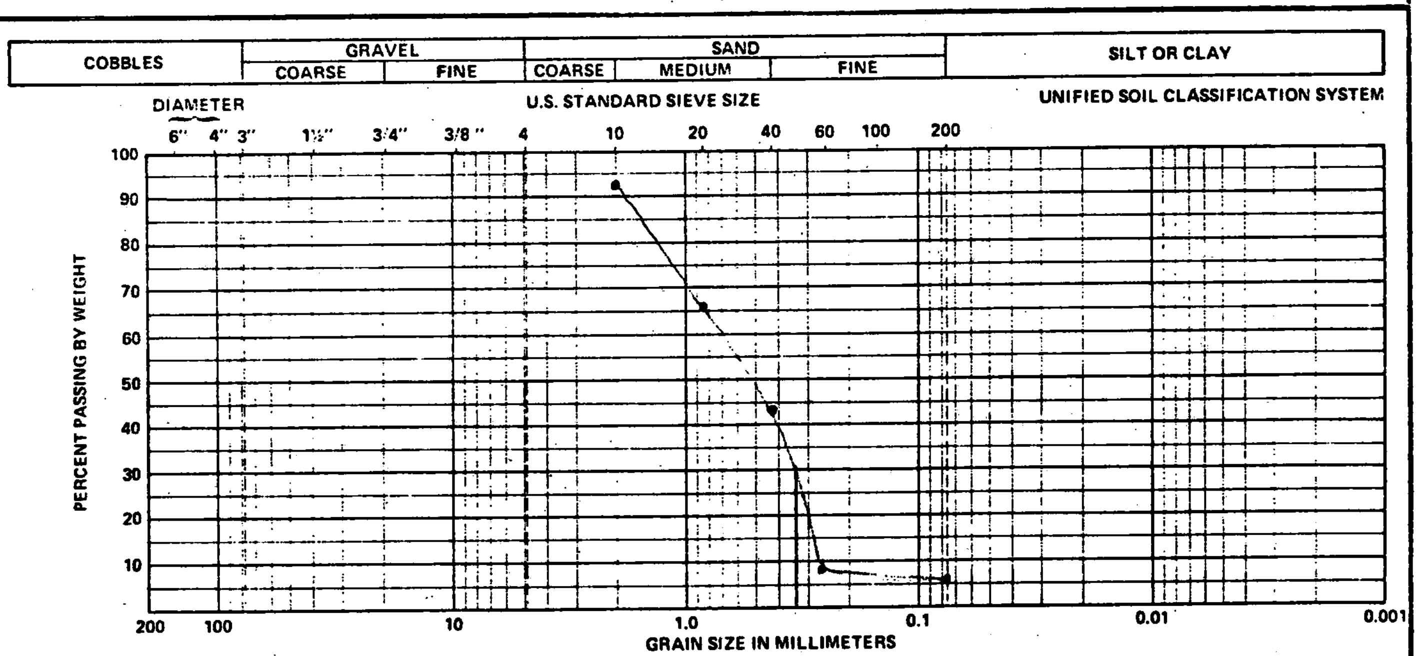


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-3	SS-16	30-32					

PARTICLE-SIZE DISTRIBUTION

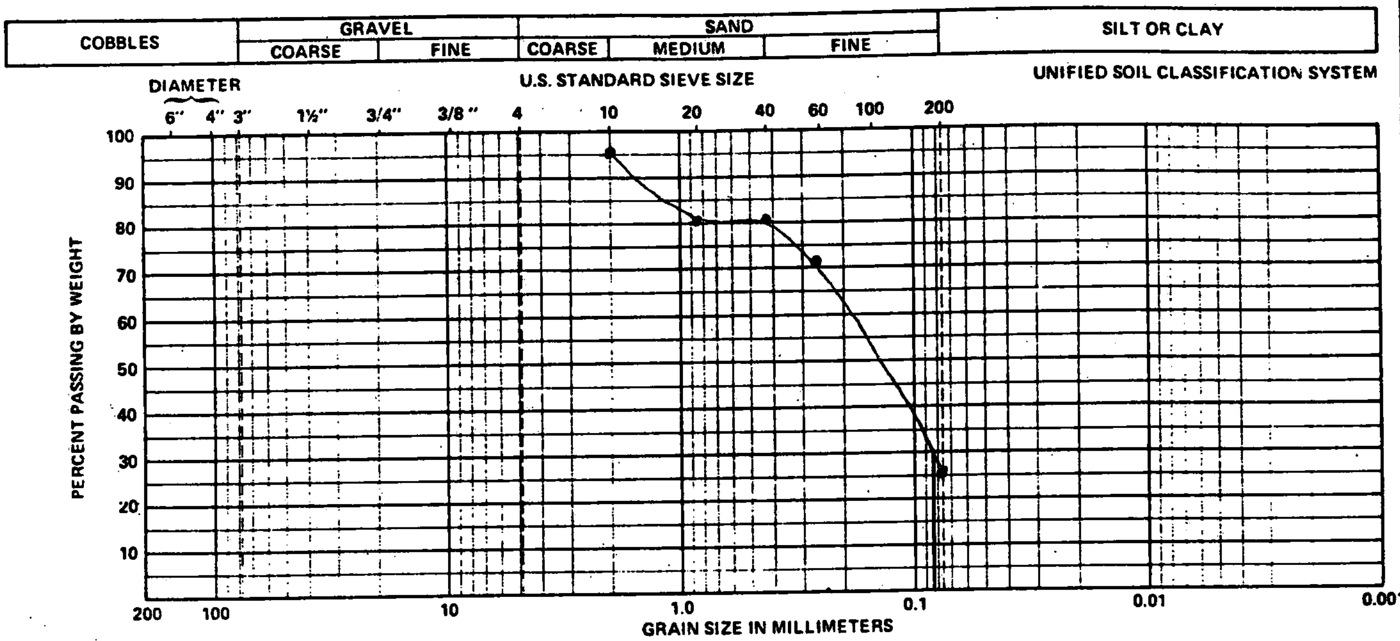


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-3	4-6		D_{30} (sand pack) = (0.6)(6) = 3.6			
				Morie #2; 40-slot			

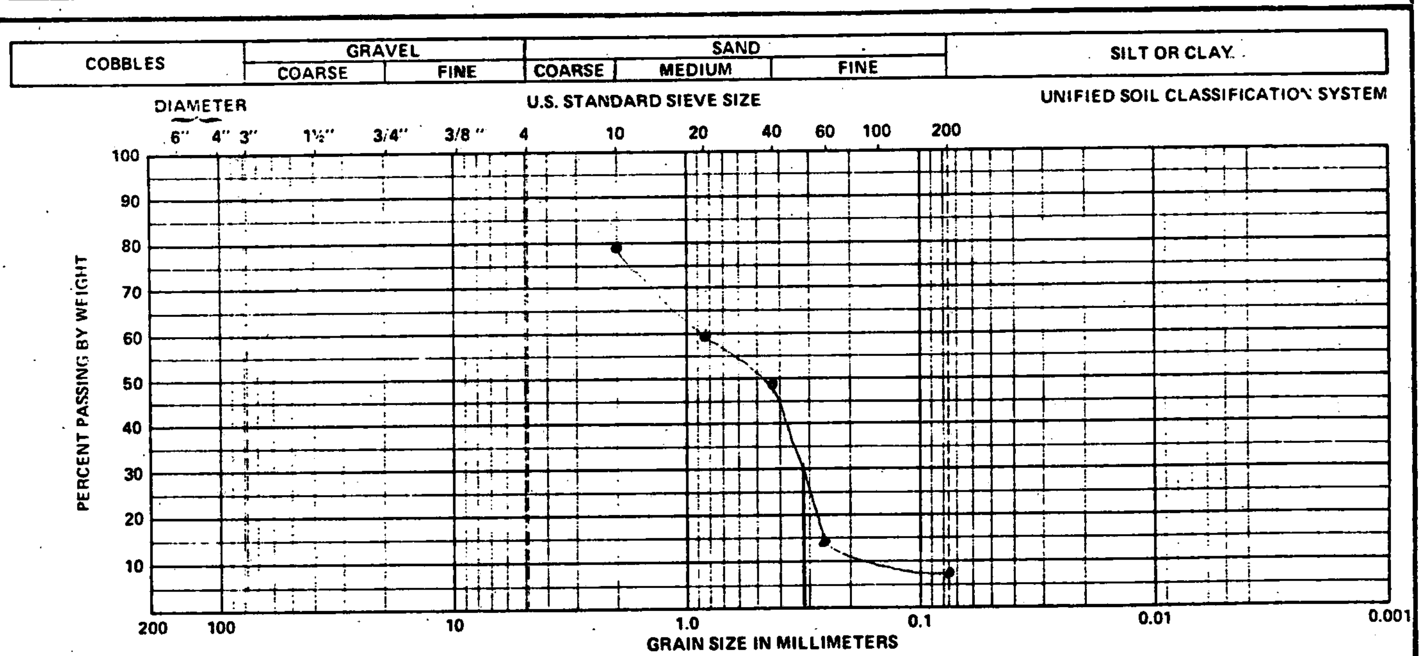


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-4B	6-8		D_{30} (sand pack) = (0.34)(6) = 2.04			
				Morie #2; 40-slot			

PARTICLE-SIZE DISTRIBUTION



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-5B	8-10		D_{30} (sand pack) = (0.084)(6) = 0.504			
				Morie #00; 10-slot			

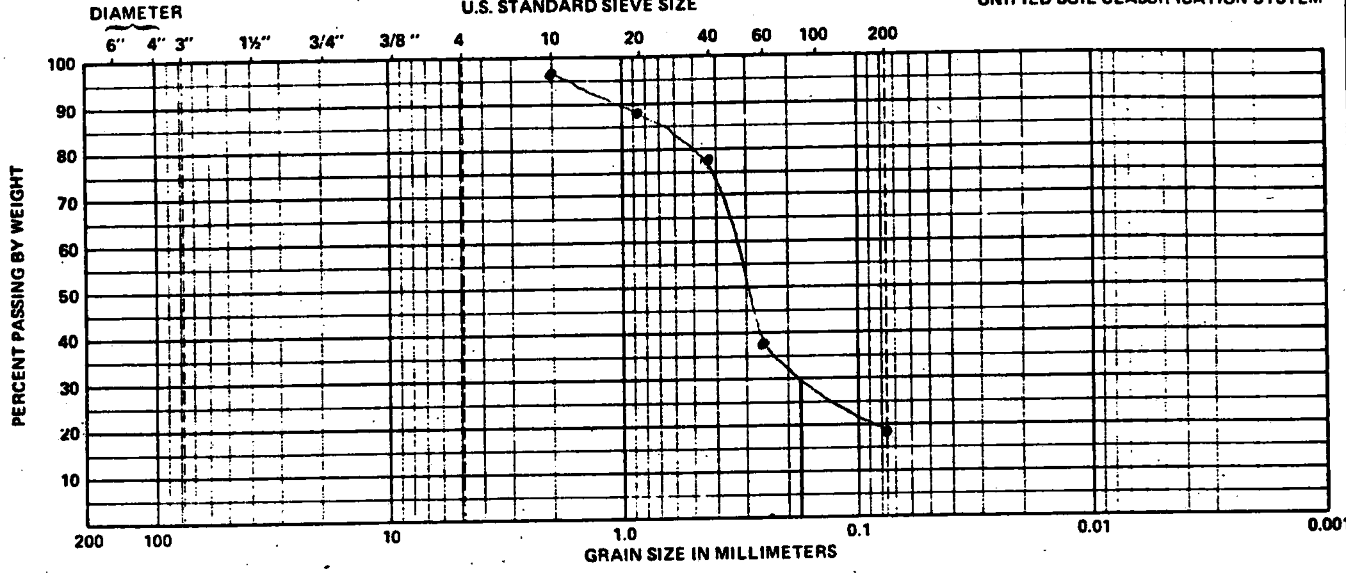


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-6A	10-12		D_{30} (sand pack) = (0.32)(4) = 1.28			
				Morie #1; 30-slot			

PARTICLE-SIZE DISTRIBUTION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

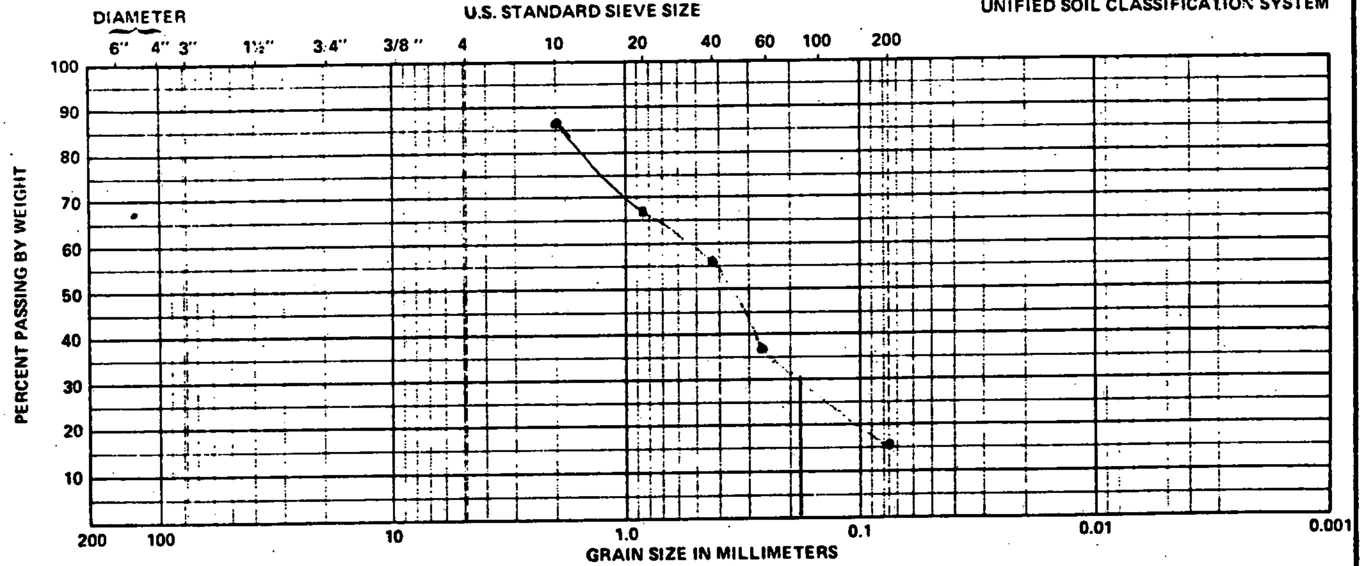
UNIFIED SOIL CLASSIFICATION SYSTEM



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-6B	10-12		D_{30}(sand pack) = (0.18)(4) = 0.72			
				Morie #0; 20-slot			

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

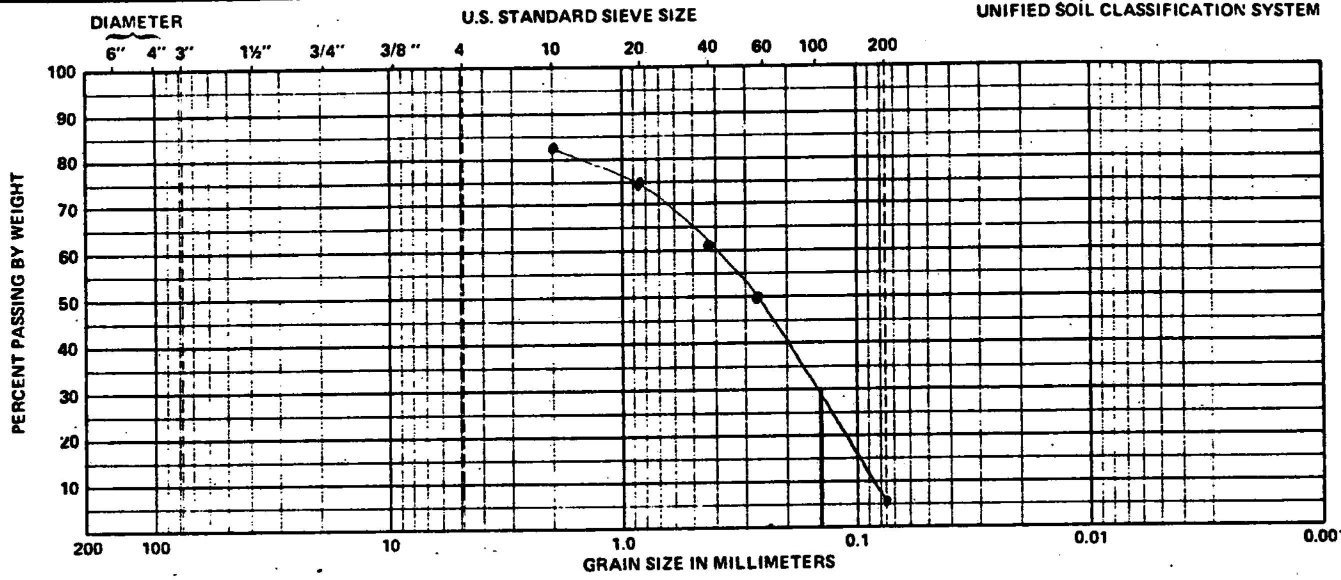
UNIFIED SOIL CLASSIFICATION SYSTEM



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-7	12-14		D_{30}(sand pack) = (0.18)(4) = 0.72			
				Morie #0; 20-slot			

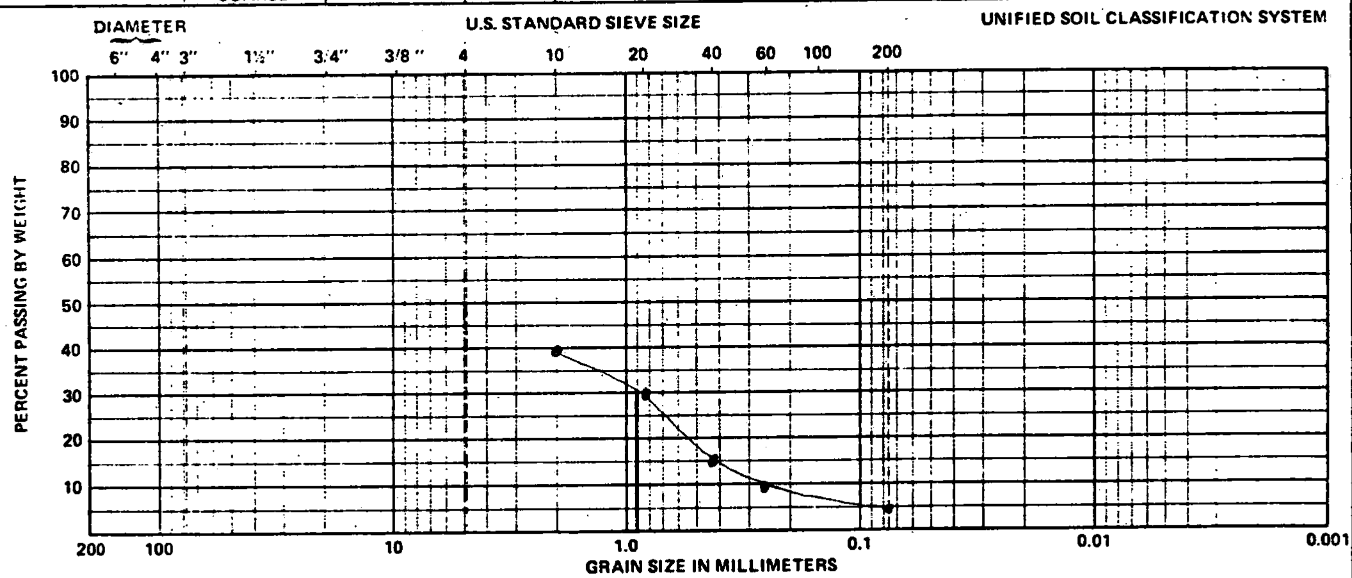
PARTICLE-SIZE DISTRIBUTION

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	



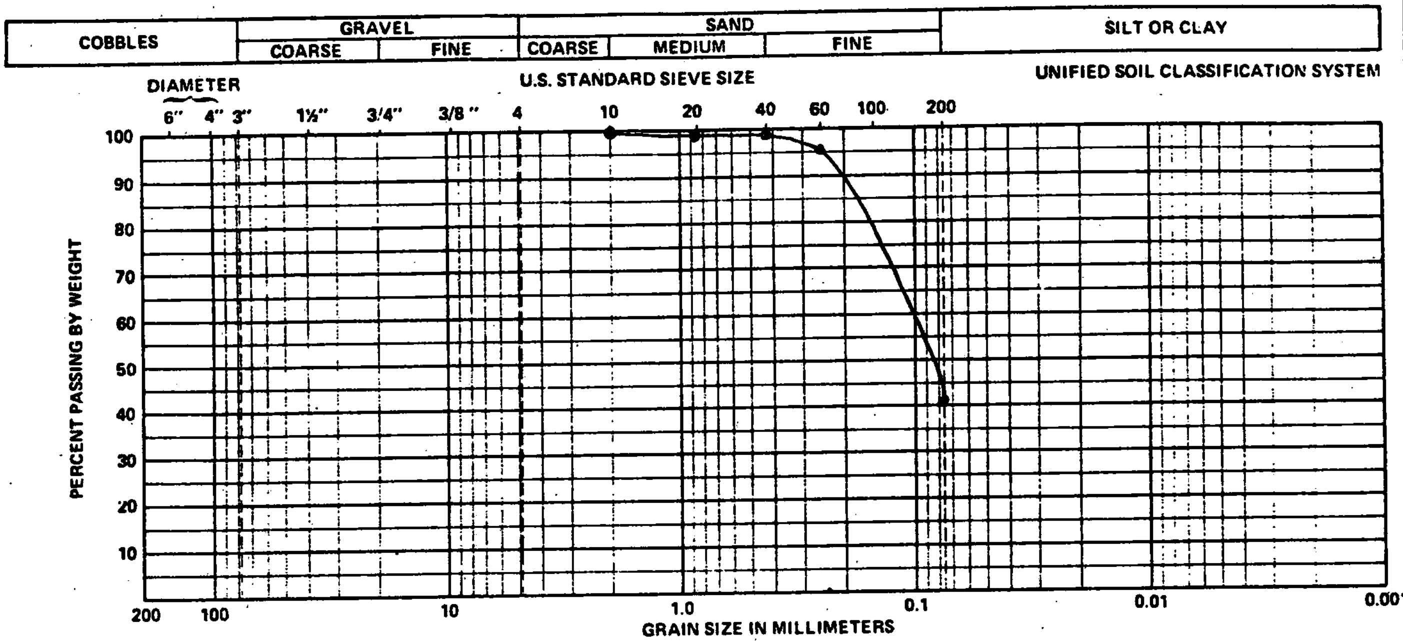
BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-8A	14-16		D_{30}(sand pack) = (0.15)(6) = 0.9			
				Morie #0; 20-slot			

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

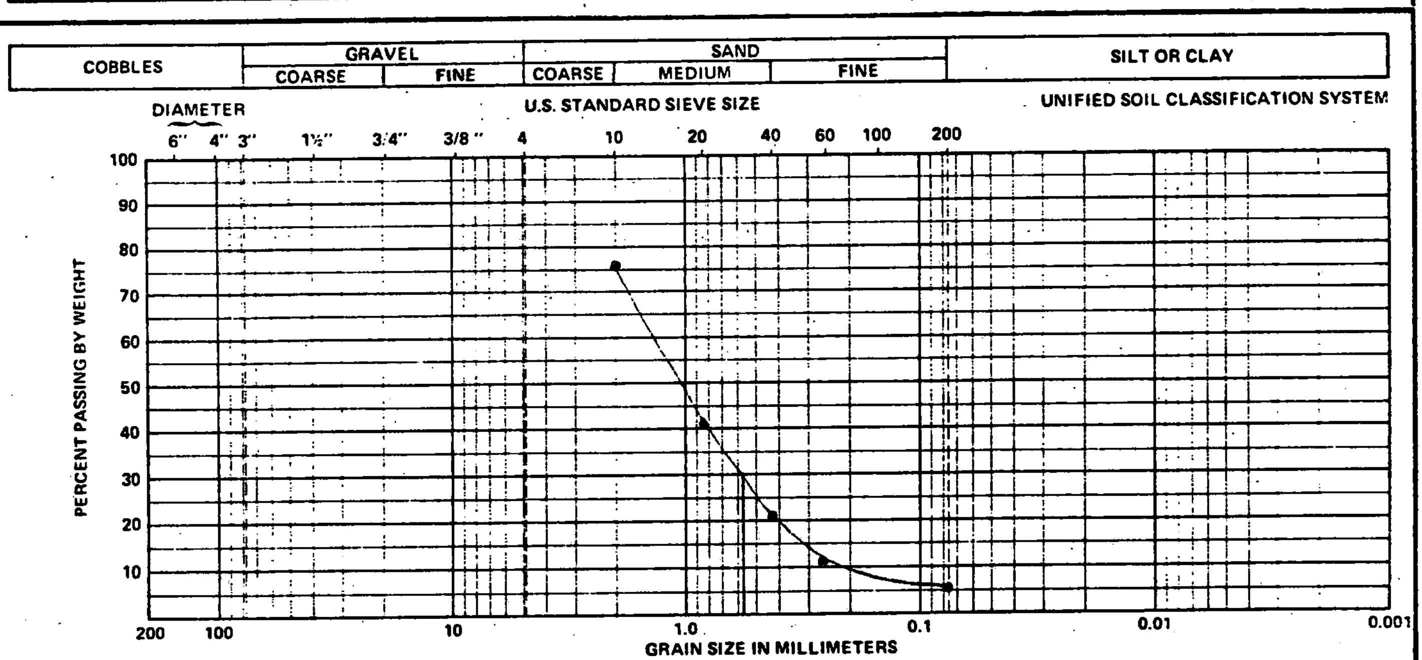


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-8B	14-16		D_{30}(sand pack) = (0.9)(6) = 5.4			
				Morie #2; 40-slot			

PARTICLE-SIZE DISTRIBUTION

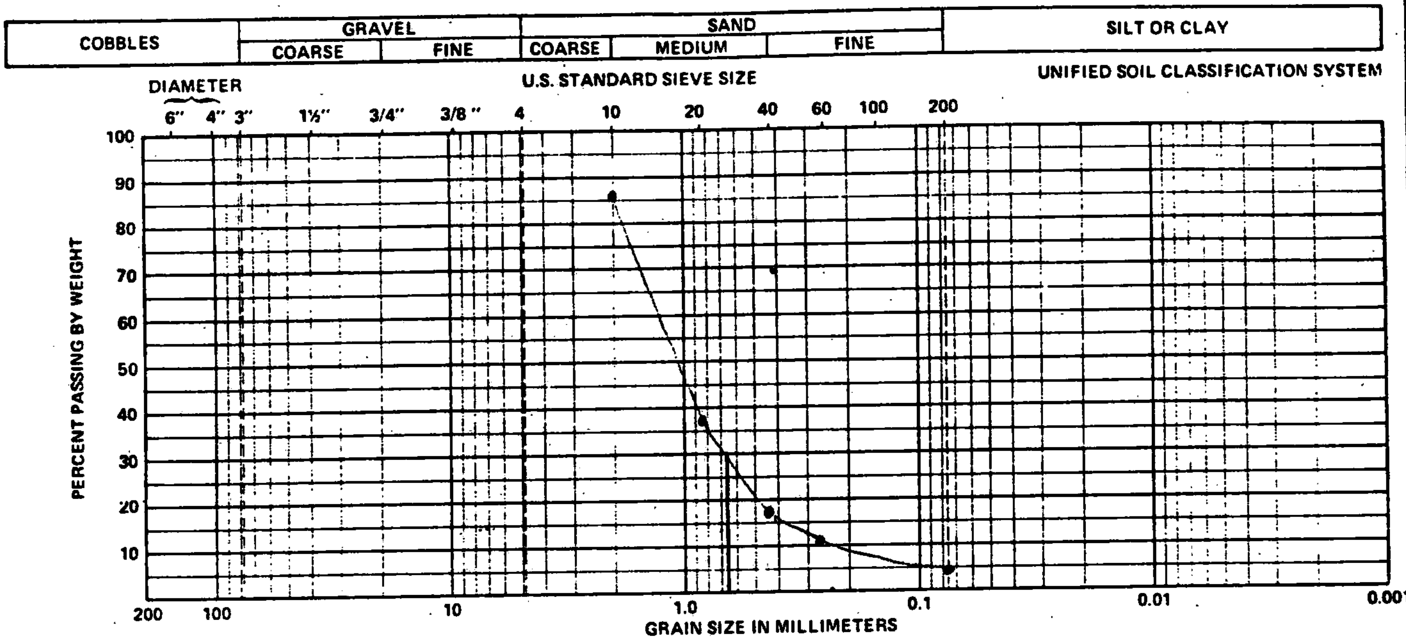


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-13	24-26					

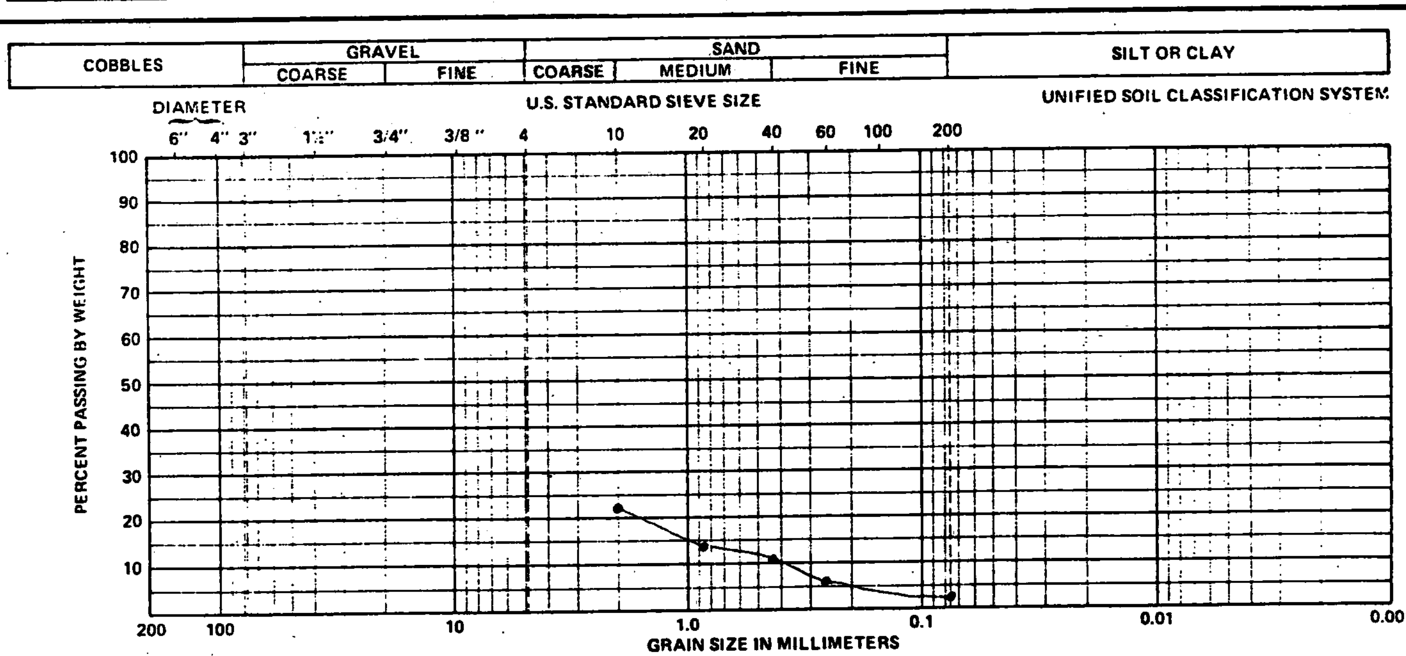


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-17	32-34		D_{30} (sand pack) = (0.57)(5) = 2.85			
				Morie #2; 40-slot			

PARTICLE-SIZE DISTRIBUTION

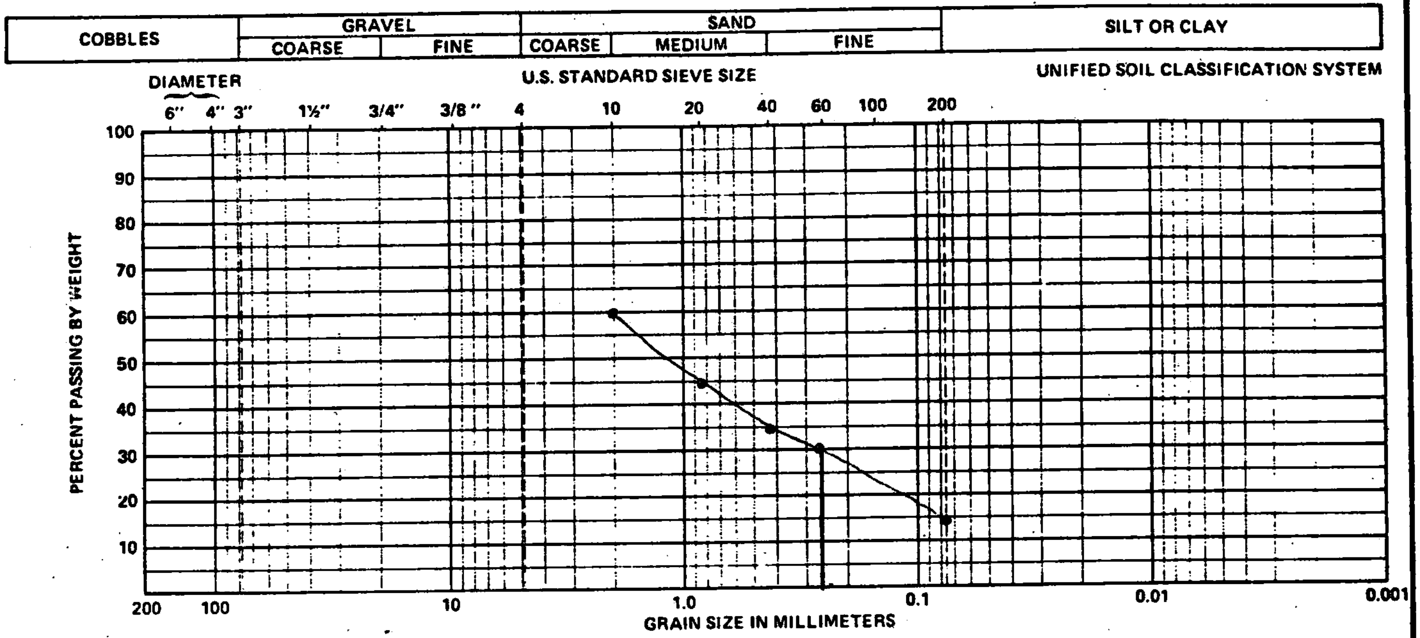


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-18A	34-36		D30 (sand pack) = (0.67)(5) = 3.35			
				Morie #2; 40-slot			

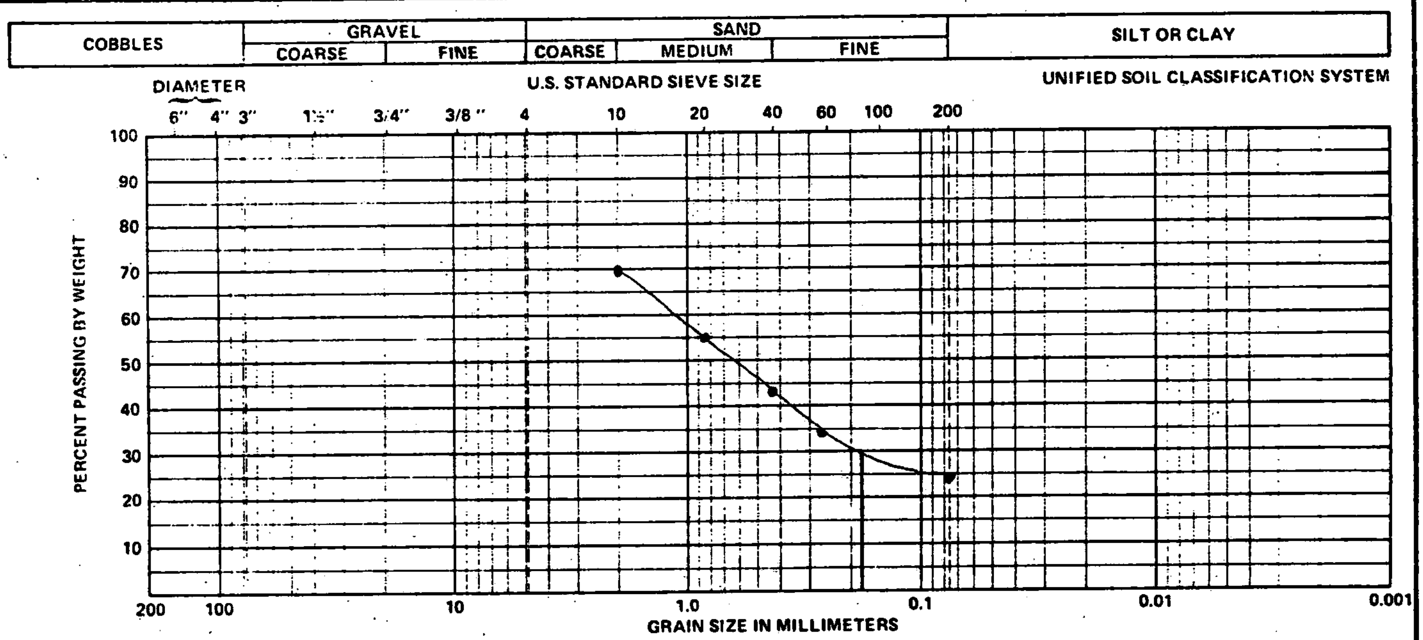


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-18B	34-36					

PARTICLE-SIZE DISTRIBUTION

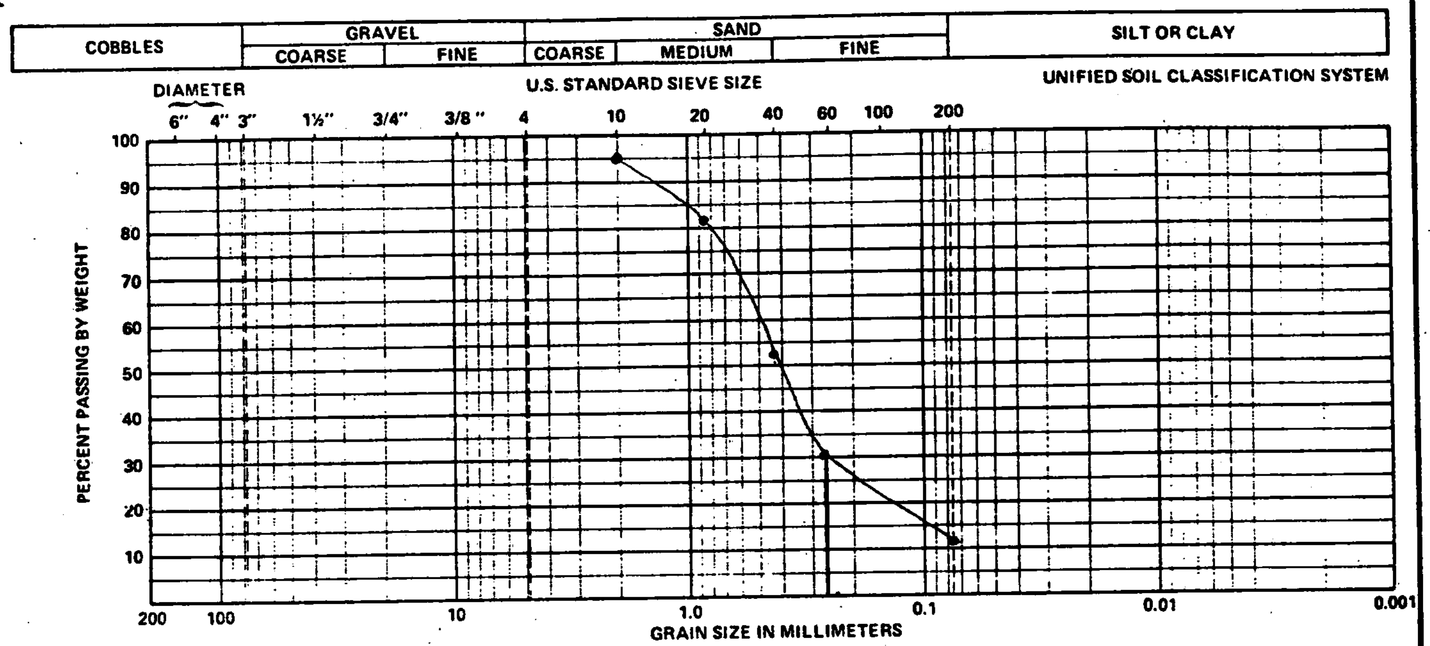


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-19	36-38		D_{30}(sand pack) = (0.27)(5) = 1.35			
				Morie #2; 40-slot			

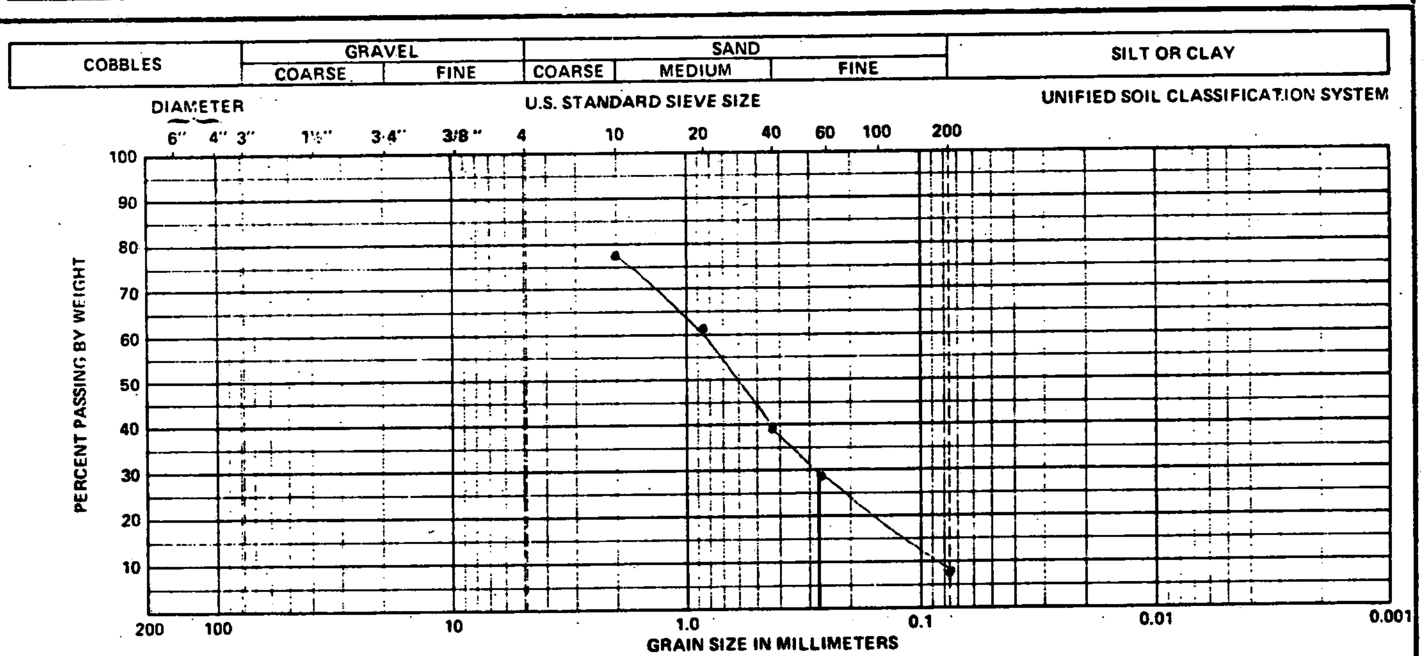


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-20A	38-40		D_{30} (sand pack) = (0.19)(6) = 1.14			
				Morie #1; 30-slot			

PARTICLE-SIZE DISTRIBUTION

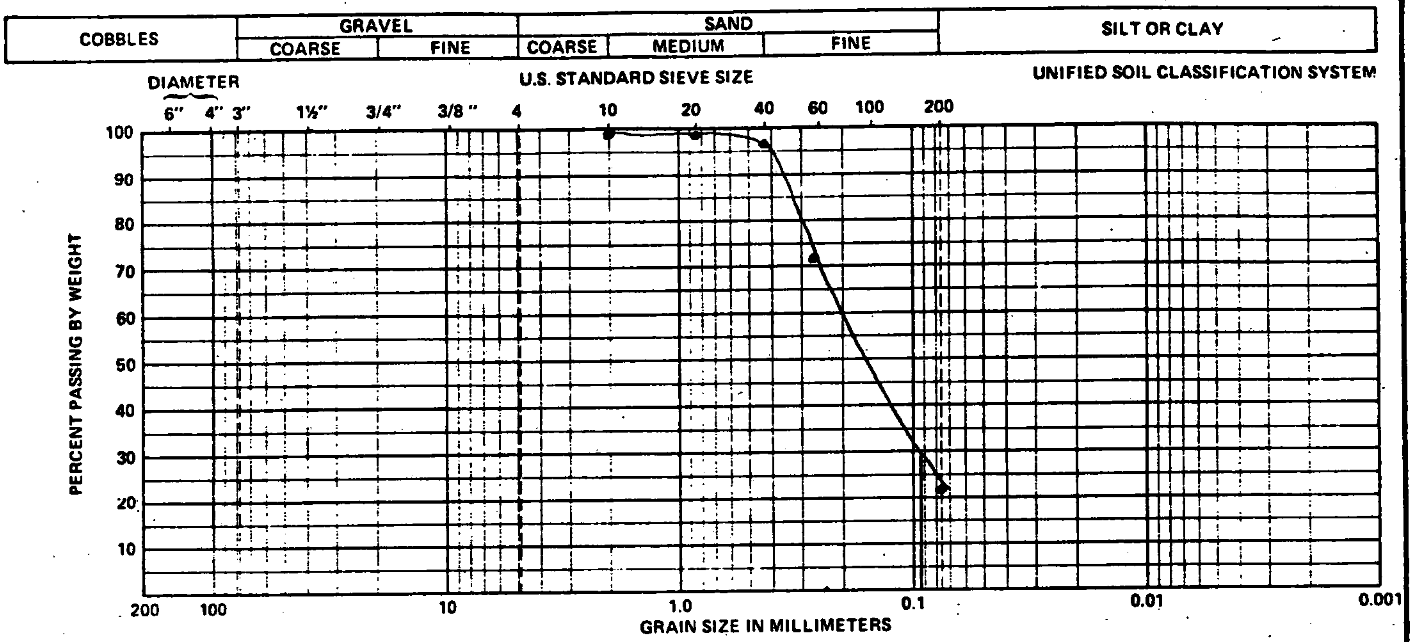


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-20B	38-40		D_{30} (sand pack) = (0.27)(6) = 1.62			
				Morie #2; 40-slot			

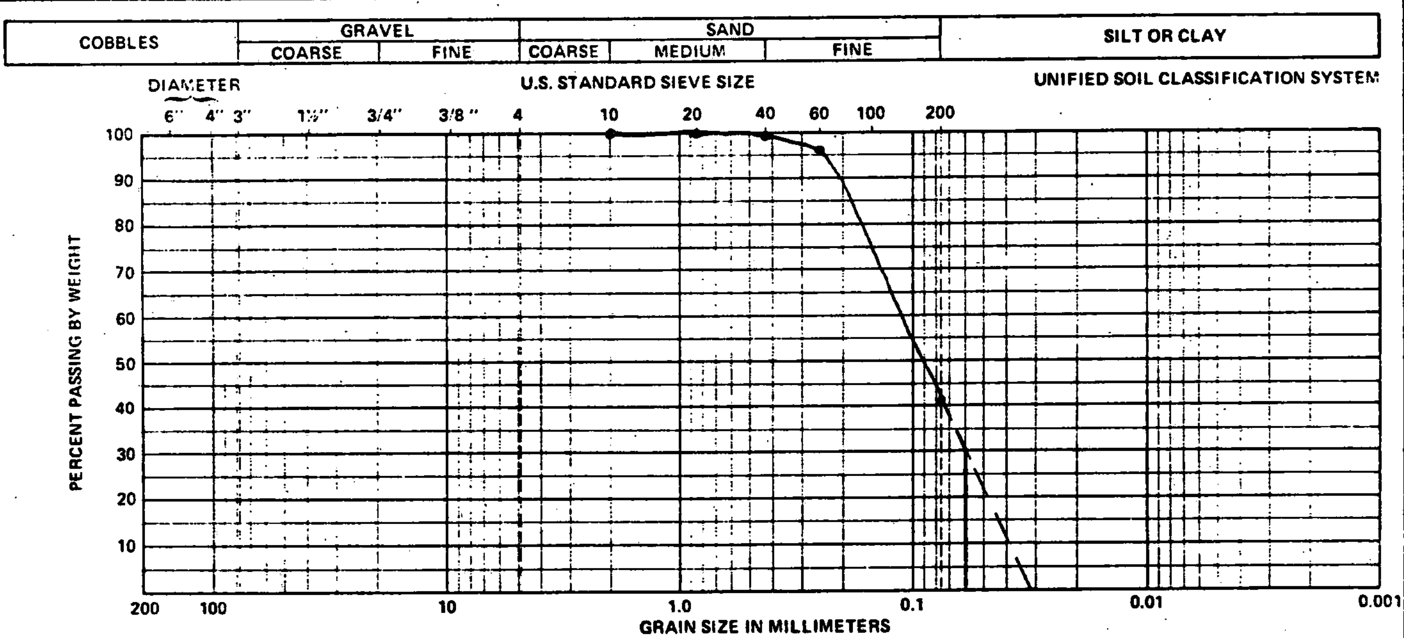


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-21A	40-42		D_{30} (sand pack) = (0.28)(4) = 1.12			
				Morie #1; 30-slot			

PARTICLE-SIZE DISTRIBUTION

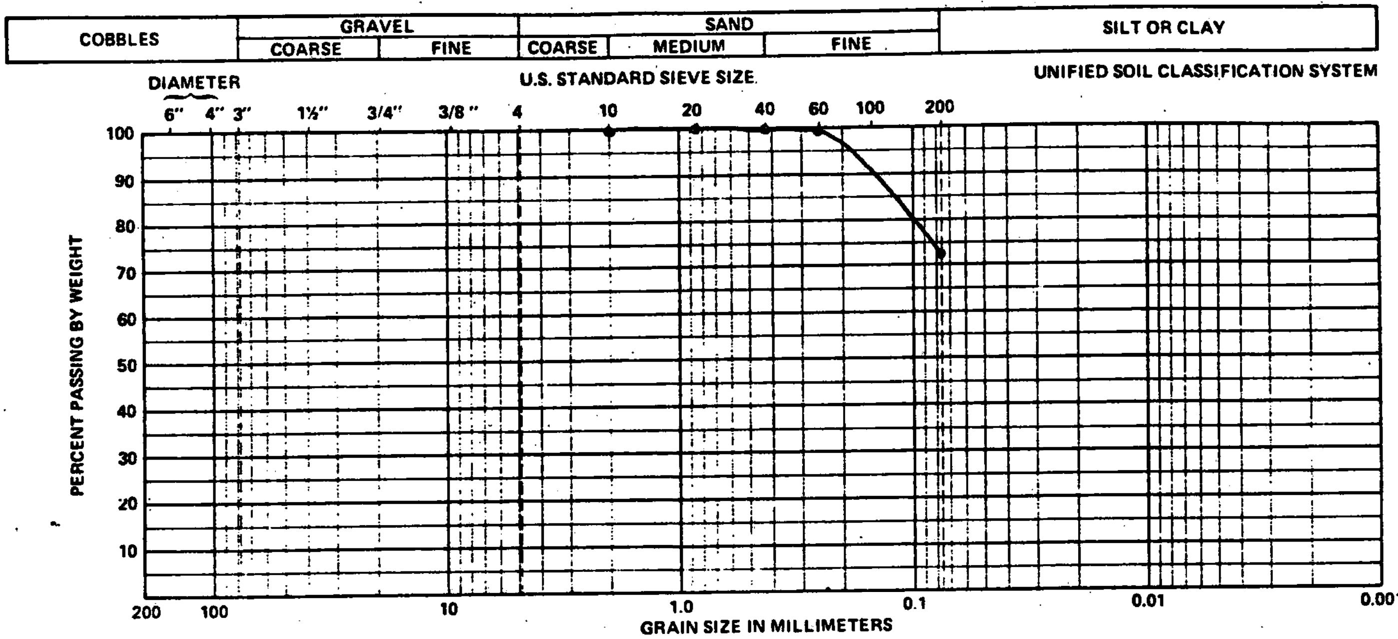


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-21B			D_{30} (sand pack) = (0.095)(4) = 0.38			
				Morie #00; 10-slot			

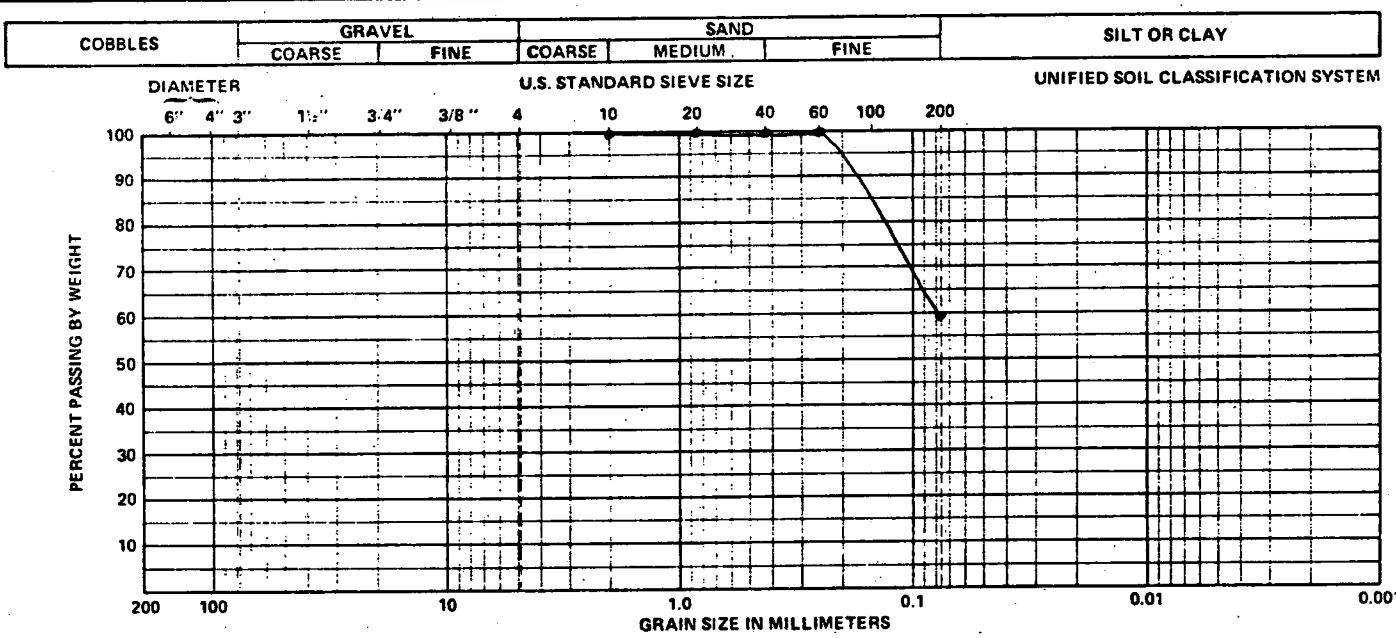


BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-22A			D_{30} (sand pack) = (0.06)(4) = 0.24			
				Blank			

PARTICLE-SIZE DISTRIBUTION



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-22B	42-44		Blank			



BORING	SAMPLE	DEPTH (ft)	SYMBOL	CLASSIFICATION	w (%)	w_L (%)	w_P (%)
RC-5	SS-23	44-46		Blank			